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A study of the innovation process within the construction project environment

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A STUDY OF THE INNOVATION PROCESS WITHIN THE CONSTRUCTION PROJECT ENVIRONMENT

BY

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Declaration

I hereby declare that this thesis had been compiled by me, that it is a record of my work completed by me, and that it has not previously been accepted for a higher degree at this University or any other institution of learning.

[redacted]

Craig Thomson

Certificate

This is to certify that Craig Thomson has done this research under my supervision, and that he has fulfilled the conditions of Ordinance 14 of the University of Dundee, so that he is qualified to submit for the Degree of Doctor of Philosophy.

[redacted]

A. K. Munns

Abstract

Over the last decade the low levels of innovation observed within the construction industry have been identified as potentially threatening the long- term future and sustainability of the industry. The root of the problem centres not on its idea generation or creativity capabilities, but on an inability to implement and manage the innovation process. Construction management is identified as focusing predominantly on 'innovation' and its management implications within three predominant lines of enquiry; by focusing on specific types of innovation, from an institutional viewpoint and from an emerging organisational perspective, and therefore neglecting a project focus. Academics expressed concern that this failure was aligned to a wider failure to understand the realities of managing innovation within the project environment as a mode of production. This thesis aims to understand the conceptual existence of innovation within the project environment, and to develop an understanding of the nature of the interaction of the innovation process and its management within the wider processes and requirements of the project. The research sought to develop a set of attributes for innovation in projects, assess the possibility of developing a model of the innovation process, and a set of management success factors.

A qualitative research approach was adopted using the principles of grounded theory, with the objective of allowing an understanding of the innovation process to emerge within the context of the construction project. A representative sample of nine case studies were selected and considered using a longitudinal approach. 75 semi- structured interviews were conducted across the case studies and analysed using grounded theory. A pilot study of analysis techniques revealed the value of applying the Nvivo software

package to assist in the handling of complex data and an advanced cross comparison of the influence of the individual attributes.

The thesis presents a generic model of the innovation process, highlighting the factors of influence and management requirements for its successful management. The model is structured as a linear process model, with four phases (initial, formulation and development, implementation and handover) with the boundaries between each determined by a decision gate. Two layers of management were observed for each phase, the phase specific management control system and the overall innovation management. Emphasis was placed on the inclusion of feedback within the model, highlighted at all levels and phases of the process. The research observed the contrasting nature of the integration of the innovation and project processes for the different innovation types, highlighting the varying significance of the activities of the process depending on the form of the attribute. The model displayed a generic structure, however it was observed that within each phase the nature of the activities and influencing factors were fluid and fuzzy, determined by the contextual nature of the attributes.

22 generic management success factors were identified across the innovation process divided into strategic, structural and cultural factors. Analysis observed that the significance for management of each of these factors varied depending on the influence of the form of each of the attributes. Key success factors for facilitating the form of each attribute were presented, however evidence suggested that only by considering the influence of the attributes as a set would successful management be achieved. A management facilitation grid is presented to aid practitioners in identifying the nature of

an appropriate management response, representative of the requirements of the particular context.

The findings of this research present the opportunity for the further investigation of its specifics and wider implications as it marks merely the starting point of our understanding. An expansion of the number of case studies would provide the opportunity to increase the focus on the specifics of the research and allow for the widening of its scope to include for example, the role of SME's and the implications of the supply- chain. However, it is the potential offered within the research by taking its findings back to the industry for practical consideration that is particularly exciting. The adoption of its principles within practical examples would further the development of the model and the understanding of its practical relevance. Further, the findings of the research have the potential to be developed into training packages for those managing innovation, with particular reference to the use of the management facilitation grid as a tool.

Chapter 1

1 Introduction and thesis plan

1.1 Introduction

The need to improve the level of innovation within the construction industry has been a source of discussion within the U.K., both academically and industrially, over the past decade. The significance of this has raised the awareness that the current low levels of innovation have a negative influence on wider problems such as productivity, quality and the increasing difficulties within project management (Nam and Tatum, 1989). These low levels feature as concerns within reports such as Egan (1998) and Fairclough (2002) which acknowledge the need to break away from time- honoured traditions (Chinowsky, 2001) and embrace the ever changing environment in which modern businesses operate. Gann (2000) and Nam and Tatum (1989) have cited the low levels of innovation as a symptom of an industry that has failed to acknowledge and adapt to market needs and change its practices. This need to improve the levels of innovation within construction has been representative of the wider agenda of 'rethinking' the nature of construction, to address the wider competitiveness problems.

Construction as a mode of production is largely founded on the principles of problem-solving (Koskela and Vrijhoef, 2001) and operates in a largely one off project environment (Gann and Salter, 2000), conditions that require a high degree of creativity at all levels of a project team (Slaughter, 1998). However, academics such as Nam and Tatum (1989), Mitropoulos and Tatum (2000), Gann (2000) and Winch (2000) suggest that the low level of innovation within construction is not related to levels of idea creation or creativity, but rooted in the industry's inability to effectively adopt and utilise innovations. This apparent failure to effectively manage the implementation process of innovation is a situation restricting the potential for change and improvement.

This thesis investigates the effective implementation of innovations within construction, by assessing the problem from a project perspective. Koskela and Vrijhoef (2001) argued that the majority of research tackling the innovation problem has been focused either at strategic or industry levels, or on particular types of innovations. As a result, it has failed to understand the implementation problem within the project environment. The work of Gann and Salter (2000) and Gann (2000) has been significant in highlighting the need to understand innovation within project- based industries such as construction. Langford (2000) observed that the construction market has changed markedly over the last 40 years; however, Koskela and Vrijhoef (2001) identified that the industry's understanding of its mode of production has failed to reflect this. There is a need to develop an understanding that allows us to tailor the management needs of the innovation process to suit the realities of this context. Slaughter (1998) argued that construction has been guilty of applying manufacturing theories and understandings of innovation without appreciating fully the distinctions and requirements of the construction project environment. The construction project is a dynamic and complex environment, existing in a largely temporary and unique form, very distinct from that of the organisationally driven manufacturing process. There is a need to develop an understanding of the innovation process that emerges based on the realities of this context.

1.2 Aim and objectives

The principle aim of this research is to understand the nature and management requirements of innovation within the construction project environment.

The following objectives are required to achieve this overall aim

- Identify the nature of innovation and the impact of project attributes

- Develop a model of the innovation process

- Assess the impact on the model of different types of innovation

- Identify the management success factors for the innovation process

- Identify the relationship between the management success factors and the innovation and project attributes

1.3 Layout of the thesis

Chapter 1 has set out to introduce the research area, through the identification of the problem currently facing construction regarding innovation, and to outline the layout of the thesis.

Chapter 2 aims to provide a review of the existence of innovation within the construction environment, with the aims of highlighting the importance of innovation to the construction industry, considering innovation as a process requiring management and assessing the innovation problem within the project environment. This discussion will draw attention to the needs for defining of the innovation concept, assessing the research and theoretical modelling of innovation within general management and understanding the implications that the construction project environment places on the concept in practice.

Chapter 3 aims to draw on the concepts and observations identified within the literature review, and logically construct the framework for a research project capable of adding to and advancing the existing knowledge base relating to construction innovation. The chapter will outline attributes for both the nature of innovation within the construction project environment and the nature of the project environment on the innovation process. The remainder of the chapter will provide a description of the research project, laying out the objectives required to achieve this overall aim.

The methodology discussion within this thesis is divided into two chapters.

Chapter 4 will examine the theoretical framework and conceptual basis behind the intended methodology, evaluating the difficulties of modelling complexity, the use of a qualitative research approach, the use of a case- study approach, and the justification for using grounded theory as a selected method for analysis. This chapter will also conduct an evaluation of the use of qualitative software to assist the analysis process.

Chapter 5 will provide a review of the practical implications of adopting the methodologies outlined in the previous chapter. The first section of the chapter will review the nature of the methodology in practice, in addition to providing a comparison of the manual method and the use of the software during the grounded theory analysis. The second section provides a review of the selection criteria for the case studies, and the considerations in achieving a representative sample.

Chapter 6 will present the research model for managing the innovation process illustrating the structure and characteristics of the process. The chapter will assess the key elements of the model, identifying the activities and factors of influence and highlighting the management requirements for the facilitation. In addition to identifying the individual phases of the model, the discussion will also outline two layers of management controlling the process.

Chapter 7 will contrast the nature of the integration between the innovation and project processes for the different types of innovation. This chapter aims to identify the project process model, and to present structural models illustrating the integration between the innovation and the project processes. The implications of this relationship will be considered with regard to the overall management of the integration, in addition to assessing the influence that this has on the nature of the individual phases of the process.

Chapter 8 aims to provide a validation of the model and its implications. This chapter will verify the research model through comparison with four general management innovation models, each representative of the four principle modelling styles for the innovation process. The principles of the four styles of representation will be imposed onto the research findings, and an evaluation conducted with the principles of the research model. This chapter will discuss these implications and assess the potential for improvements to be made to the research model.

Chapter 9 presents the 22 generic success factors developed from the research for the effective management of the innovation process within the construction project environment. Each factor is evaluated individually and in addition to their overall nature being validated against established success factors developed within other research contexts. The attributes identified in chapter 3 are re- evaluated following analysis, with each individually assessed for their influence on the management of the innovation process within this environment. The assessment will provide identification of the generic success factors requiring additional management facilitation to mitigate the influence of each attribute. A management facilitation grid will be presented allowing practitioners the opportunity to identify the facilitation requirements of the process reflective of the nature of the attributes.

Chapter 10 will present the conclusions and suggest recommendations for future research.

Chapter 2

2 Literature Review

2.1 Introduction

Nam and Tatum (1989) suggest that to explore the nature of innovation within construction it is necessary to identify the problem as rooted in the industry's failure to effectively manage its adoption. This observation provides a focus and incentive for both the research community and industrial practitioners to address the problem. This chapter will provide firstly a review of innovation as a general management concept, by a) highlighting the importance of defining the innovation concept and b) assessing the research and theoretical modelling of innovation within this perspective. This places considerable emphasis on the need to understand the theoretical foundations of innovation as a concept, prior to embarking on the second part of this review, its application and implications within the construction environment. This will provide a) a background and review of the construction innovation problem, b) identify the failure of the industry to address the problem from the project perspective, and c) the implications of this neglect on the industry's failure to effectively manage the innovation process within this context.

2.2 Definition of innovation

This section aims to provide a definition for innovation as a concept in order to provide distinction from three closely related concepts, a) problem solving, b) invention and c) change.

2.2.1 Defining the concept

When defining innovation it is necessary to recognise that as a concept, it is split into two key components, firstly that it requires to be novel in the eye of the beholder, and secondly it requires to be adopted in practice. The first component is significant as it identifies that an innovation can exist if the concept is novel to those implementing it. The second component of the definition reflects that the innovation requires to be implemented in a practical situation. These components are contained effectively within Zaltman et al's (1973) widely recognised and used definition of the concept as 'an idea, practice, or material artefact perceived to be new by the relevant adoption unit'. This research adopts this definition and identifies that it is used by academics of various management fields such as Draft (1982), Damanpour and Evan (1984), Damanpour (1991), Freeman (1982), Rogers (1983), and Baskerville and Pries- Heje (2001). Tidd et al (2003) provide a definition that uses differing terminology whilst essentially representing the same two key components, i.e. 'the embodiment, combination or synthesis of knowledge in original, relevant, valued new products, processes or services'. In addition to the two key components, these definitions also highlight the fact that innovation by its nature is not confined to being a product or a process, but can exist as a service, an idea or knowledge, as long as it is novel to those involved and adopted in practice.

The identification of the two components is necessary from a management perspective as they form the distinction between innovation and three although similar, commonly confused concepts.

2.2.2 Problem solving, invention and change

The concepts of innovation, problem solving, invention and change display many similarities and a danger exists that they may be confused in practice. Although this research will solely consider innovation, it is necessary to demonstrate the distinctions of the terms conceptually and identify that potentially these will require different management approaches and requirements.

2.2.2.1 Problem solving

Problem solving as a concept can be defined as the activity or process of 'resolving a doubt or difficult matter' (adapted from Oxford Compact English Dictionary, 1996). It is necessary to acknowledge two differences between the concepts of problem solving and innovation. Firstly, although innovation often may originate through problem solving activity, to be regarded as an innovation there requires to be a new piece of thinking (for those involved), whereas this is not a requirement of problem solving. Secondly, there is a requirement for an innovation to be applicable to different situations, whereas problem solving can remain specific to the given situation. Due to these two distinctions, it is necessary that the management requirements of each activity reflect this. Tidd et al (2003) argued that management needs to understand that innovation requires a distinct approach reflective of its unique needs as a concept. Potentially, this is an aspect of innovation management where construction has not been very successful, as it displays such low levels of innovation (Nam and Tatum, 1989) within a mode of production that is dominated by activities of problem solving.

2.2.2.2 Invention

Tidd et al (2003) distinguish between innovation and invention through firstly, an invention is not an innovation unless it has actually been used in adoption and secondly, an innovation requires only to be novel to those adopting it whereas an invention requires to be novel to the existing arts. This is a distinction that has been observed within construction by Slaughter (1998) who added that innovation does not require a detailed design or physical manifestation, and it does not have to be novel with respect to the existing arts, only to the creating institution.

2.2.2.3 Change

The concept of change is defined as 'the act or instance of making or becoming different' (Oxford Compact English Dictionary, 1996). This definition provides similarity to that of innovation in that it requires to be a change that is implemented within the unit of adoption. However, it is clear that change need not contain an element of novelty for the unit of adoption, as there may be previous experience present. Change from a creative point of view will be imported from out with the unit of adoption, with a team representing familiarity and some level of experience of the change. Innovation, on the other hand, can be generated both internally and externally, but will have a team with no previous experience of the innovation within the unit of adoption and regard it as new or novel to them.

2.3 Modelling innovation

Before exploring innovation within the context of construction and its project environment, a review of the theoretical understanding of the concept from a general management perspective is provided. This will consider the dynamics and complexities of the existence of innovation, identifying the value of producing a model for the development of an understanding of both the concept and its management implications. This section will outline 1) innovation as a process, 2) the conceptual framework from which models of innovation are developed, and 3) review success factors produced for effectively managing the innovation process.

2.3.1 Innovation as a process

The definition provided in section 2.2.1, identified that one element of the concept of innovation as existing was the requirement for it to be adopted in practice. The likes of Tidd et al (1998) stated that all definitions of innovation stress the need to complete the development and exploitation aspects of new knowledge, not just invention. The definition suggests that innovation as a concept exists as a process that requires to be managed from its inception until its termination of use. This idea was supported by Rogers (1983) who argued that the innovation process requires to contain both the initiation and the implementation phases. Indeed this assessment is backed by Thomas Alva Edision (cited by Tidd et al, 1998) who stated that the challenge in innovation was not just concerned with invention, but that it was the process of growing them into practical use. Utterback (1994) attempted also to understand the dynamics of innovation and displayed his understandings of innovation as a process.

Historically much of the research into understanding innovation and the theoretical evolution of innovation as a process has been predominantly in the context of the organisation. Utterback (1994) for example like much of the understandings of innovation directly links the path of the innovation process and its development to that of the organisation's process or development path. The connection to the firm and the organisational context, has formed the basis for the works of Kanter (1983) and Burns and Stalker (1995). They connect the ability to manage the innovation process as a strategic tool for organisational success, and the need for cultural change to ensure that they improve their management of it.

Focusing on the innovation process within the organisational context has resulted in its association with the achievement of competitive advantage. As a result, it has been tied to understandings based on product development and entrepreneurship. Utterback (1994) was particularly influential as he suggested that product and process innovations occur at differing periods of the organisational process. He also highlighted the contextual difference between assembled products and non- assembled products. Utterback's observations influence the understanding of innovation with the realisation that different types of innovations often require a different set of management considerations.

Research within this context identified that innovation exists as a process divided into several different phases and stages. Product development models such as those identified by Utterback (1994), Wheelwright and Clark (1995) and Cooper (2001), all represented the process of product development within organisations as existing in several different phases. Although each model used differing terminology for their description of each phase, it is clear that this reflects the empirical specifics of the context that is being represented by the model. Each phase representing a set of specific process activities and management requirements tailored to the needs of each phase. Although this style of modelling stemmed from the context of product development with relation to innovation, general management has been guided predominantly by the use of phased process models in wider theory, with good examples of this being the likes of Huber's (1980) decision- making model.

Gann and Salter (2000) have been influential in identifying that project based industries have been neglected within general management, due to the predominance of assessing the innovation process within the context of the organisation. Gann and Salter (2000) argue that within a project, the structural and cultural alignment of the innovation as a process is far more complex than that of the organisational understanding. This discussion was directed towards a general management audience; however, their research focus dealt with construction. As a result integrating the innovation process within the construction project has the potential to be far more complex than many expect, and therefore requires examination.

Prior to assessing the conceptual framework for modelling innovation within the next section, the context behind much of the generation of this understanding should be noted. This section has observed that research into this area is predominantly based empirically on the process of product development within the organisational environment. This needs to be recognised, particularly when considering innovation within a context that is different. Researchers of innovation within project based sectors such as construction should recognise that many of the established models might not be representative of their industrial realities. It is essential therefore, that in observing the lessons of the models, it is not assumed that the processes are the same within the different contexts. The following section will develop this argument further and will suggest that each model is merely a representation of the context to which it is set, and that application to different contexts that are not appropriate has the potential to be empirically dangerous. Recognition of this understanding allows the researcher perspective and an appreciation of the importance of observing the context to which many of the foundations of innovation thinking were generated.

2.3.2 Conceptual framework for modelling innovation

The foundations for understanding the nature of the innovation process and the requirements for its management, has been established predominantly within research through the production of models. Modelling can take very different forms depending on what is intended to be represented within the research. This section aims to outline the theoretical frameworks from which these models have evolved, and will discuss the differing formats that the models have taken. The section will outline firstly the nature of modelling, and secondly the aspects of innovation modelling theory, 1) level of theory and 2) type of theory.

2.3.2.1 The nature of modelling

The use of a basic process structure (Tidd et al, 2003) for examining innovation initiatives has been influential to the evolution of innovation understanding theoretically. Poole and Van de Ven (2000) argue modelling the dynamics and complexities of the process are more useful than general theory creation. Citing Suppe (1977), Poole and Van de Ven (2000) observed that a model is a projection in detail of a theory that depicts a possible system of relationships, events or actions. The use of the word possible is of interest to the understanding of the application and value of models in practice. There is a growing argument emerging over the past few years that it is impossible to create a complete model for innovation. The likes of Tidd et al (2003), Dooley and O'Sullivan (2000) and from a construction perspective Tatum (1984) argue this, adding that no one model can adequately address all the needs of the process of innovation whatever the context.

Francis (2000) places concerns and expresses caution over the use of processes when describing an innovation development. He cited McDonald (1998) who argued that the idea of a process existing as a linear model occurring and being managed over time as wrong. McDonald (1998) identified that innovation as a process is not rooted as a 'uniform and predictable sequence, and that the idea of well constructed stages and phases or a flow chart or a systematic funnel process as being fanciful'. However, he did acknowledge that there must be a process of sorts, as ideas require to be enacted.

Francis's concerns regarding the use of models and the question over whether to regard the concept as a process ties in with a significant observation made by Baskerville and Pries- Heje (2001). Their review of innovation modelling revealed that individual models represent an innovation from a given perspective and that models should be viewed as such during analysis. When regarded within this context the value of modelling innovation is considered as important, but only when placed conceptually within their given empirical context (i.e. a representation of the decision making process, time related model, innovation process models either linear, non linear, or cyclical). Dooley and O'Sullivan (2000) argue that the focus of the given research will determine the factor that is emphasised within the model. Baskerville and Pries- Heje (2001) argued that innovation should be assessed using a multiple- theory approach, highlighting that innovation models yield rich but orthogonal representations of the underlying case. This argument suggests that a model requires to be regarded as a representation of an innovation within or from a given context, and that a more sophisticated understanding of innovation can be achieved through the adoption of differing models.

This is an important realisation and something that Poole and Van de Ven (2000) assign to in their understanding of the need to adopt a Meta theory from a varied set of models based on a) the level of analysis and b) the type of theory driving the process and c) to consider this within the context of the complexity of the process. The multi- analysis approach proposed by Baskerville and Pries- Heje (2001) demonstrates the value of such an approach with a single empirical example of an innovation process being assessed using a number of different models. They argue that the format of the model should not be mistakenly identified as the sole representation of the nature of the process, as different empirical contexts require differing representations. However, Poole and Van de Ven (2000) proposed that three switching rules require to be applied when determining which processes to apply to explain innovation processes over time. They argue that different models can be applied over the course of an innovation process, and the rules that need to be satisfied are by type, temporal, and spatial rules. Tatum (1984) suggests a similar approach stressing the necessity for robust research to use other studies of innovation in order to achieve a complete understanding.

When aiming to model or purely understand innovation within a project environment, Gann and Salter (2000) argue that it is best to consider innovation as acting as a process. However, Poole and Van de Ven (2000) observed the need to understand when considering innovation's as a process, that there requires to be an understanding that they may not necessarily observe a strict structure but that many are fuzzy by nature, and perhaps that they would be better viewed as more of a guide. Making assessments and representations within this context requires paying specific attention to the context of the situation intended for representation.

2.3.2.2 Innovation modelling theory

Poole and Van de Ven (2000) argue that innovation models are split on two aspects of theory, 1) level of theory (local + global) and 2) the type of theory (defined by its motor and style of representation).

1) Level of theory

Under their understanding, the level of innovation exists in two predominant levels, a) global (macro) and b) local (micro). They define the (a) global model as being the long-term development of the unit of analysis of the overall trajectories, path, phases or stages in development of an innovation. A global theory explains innovation development in terms of being determined in part by the existence of rules and programs in the innovations institutional context, by how the innovation process is structured by key actors as they will structure the innovation according to their schemata. The authors cite Nisbet (1970) who argues that developmentalism, epigenesist and accumulation theory, and Darwinist evolution and Marxian dialectal theory as good examples of this level of analysis. Within the context to which Poole and Van de Ven (2000) assess innovation (i.e. from an organisational perspective), they place considerable emphasis on the institutional context of innovation modelling highlighting the influence of the nature of the environment. This is also something that can be viewed within the context of construction projects, as the process will be influenced by the projects environmental influences internal as well as external.

The (b) local (micro) models are defined as the short run development, of immediate action in the innovation process, operating on short-term development patterns. These models tend to represent micro ideas, decisions, actions or events of particular development episodes. Poole and Van de Ven (2000) cited three models, Skinner (1938) stimulus- response behaviourism, Hause (1971) path- goal theory, Cohen, Mask and Olsen (1972) garbage can model of decision making, as good examples of this level of modelling. They identified this level of modelling as being neglected within the wider innovation literature.

Despite their distinctions, it is necessary to view a process when appropriate from the context of both levels as this then allows both the macro and the micro to be considered. To focus on one level would fail to account for the entire picture, as the macro and the micro levels inform each other. As researchers, there is a need to be able to regard innovation as existing potentially at different levels and to consider both the local and the global models as they complement and enjoy specific linkages (Poole and Van de Ven, 2000). When modelling the innovation process within a project based industry such as construction there is a demand to adopt an approach that accounts for both levels of theory due to the unique nature of each construction project. Each project will experience different linkages with the rest of the industry and the outside world (global or macro) and experience a unique set of characteristics internally (local or micro). Poole and Van de Ven (2000) argue that by considering these linkages will greatly aid the representation achieved through the process of model building.

Baskerville and Pries-Heje (2001) favoured to identify two views of innovation, the genealogical and ecological view, as opposed to the level of theory. They define the genealogical view as representing models and understandings of innovation based upon consensus and regulation, where as the ecological view is based on conflict and competition. These views provide more understanding of the context of the innovation process within the context of its implementation, providing greater emphasis for the management of the process. This is a different method of viewing innovation to that of the level of theory. However, it should be viewed as a perspective that is taken and considered in conjunction to this approach, as they focus on different aspects of the same situation.

When assessing different models of innovation there is a requirement to not only consider the level of theory for the model, but also to consider the level of complexity that the model is founded. The complexity of the innovation process influences the model heavily and common determinates of this are 1) size, 2) number of stakeholders, and 3) component parts (Poole and Van de Ven, 2000). Poole and Van de Ven (2000) argue that this is a feature not stressed sufficiently within the literature; however, its implications feature heavily in the type of theory that is adopted within research as models attempt to reflect the complexity of the situation.

2) Type of theory

The remainder of this section aims to review the differing format and styles of innovation models produced (type of theory), firstly (a) understanding the different motors (or logics behind) used to explain how and why development of the innovation occurs, and secondly (b) the differences between four manners of representing an innovation within a model.

a) Three motors for modelling

A motor can be defined as the logic from which the model is founded, and it reflects the drive and reasoning behind the innovation. Poole and Van de Ven (2000) identified three differing motors used when modelling innovations, i.e. a) the historical motor, b) a functional motor, and c) an emergent motor. They differentiate the three motors through the understanding that (a) the historical motor is determined through necessity, relying on analytical entailments to account for moves from stage to stage (the necessity to define the problem prior to searching for the solution, and heavy reliance on procedural rules to follow). The functional motor (b) reflects the concept of goal attainment where clear goals are defined or an end- state is understood, but with no sequence displayed. Poole and Van de Ven (2000) argued that by contrast the emergent motor (c) provided the richest and most insightful account due to its exclusive focus. When considering innovation models it is useful to understand how and why an innovation is being driven within its particular context. This is perhaps relevant when trying to understand innovations exiting within the project environment. It is necessary to assess an innovation within such a context and to consider which of the motors is representative of the realities of the situation.

b) Four modelling formats

This review has previously identified that innovation models can take a number of different formats that will vary depending on the empirical context of the model. Poole and Van de Ven (2000) identified that it is necessary for researchers to understand the style or format that an innovation model displays when assessing its representation. This sub- section will review four different formats or styles that innovation models take in an attempt to understand their distinctions, 1) non- linear, 2) linear, 3) emergent, and 4) cycle modelling.

Baskerville and Pries- Heje (2001) identified models as existing as (1) non- linear and (2) linear. Non- linear models refer to those displaying an abstraction of the factors influencing the innovation within a given context. A useful example of this is Burgelman and Sayles (1986) push/ pull model where they display the factors influencing the basis behind the innovation's development and place it into a context for understanding. The linear model is perhaps the most commonly associated with the depiction of the innovation concept as a process, and illustrates clearly defined phases and stages. Good examples of this type of model are the likes of Cooper's (2001) stage gate model, Kline (1985) link chain model, Rogers (1983) innovation diffusion model and Zaltman et al (1973). These models provide a range of management requirements and key activities that are necessary within each phase of the process. The use of a linear approach to modelling the innovation process implies that there is a sequence that naturally exists that requires to be followed. This is commonly associated with the product development based models such as Cooper (2001) and Wheelwright and Clarke (1995) as within the organisational context to which they are based the models intend to illustrate a generic procedural approach that needs to be followed by management to ensure a successful innovation process.

Over the last decade, two more fluid styles of modelling have emerged within research attempting to represent the innovation process, i.e. (3) the emergent model and the view of innovation as existing as (4) a cycle. The emergent style of modelling exemplified by Van de Ven et al's (2000) innovation journey model provides an alternative to the heavily structured representation illustrated by the linear model. The emergent model acknowledges that the process exists as a journey emerging from a series of unstructured activities and developed by passing through a series of phases. The model provides much more context on the influencing factors affecting the process and charts the level of activity over the course of the process. This method of modelling focuses far less on the management activities and tasks, and charts more the evolution of the process and its influences whether they are management or environmental considerations.

Tidd et al (1997) criticises the innovation journey model for not taking into consideration the variety of contingent circumstances and variables that can be exposed within different innovations. Tidd identified the need to consider four context variables, 1) sector (as discussed by Pavitt (1991), 2) size (Rothwell and Zegveld, 1985), 3) national systems of innovation (Landvall, 1992) and 4) lifecycle of technology and industry (Utterback, 1994). These factors are similar to those identified by Slaughter (2001) as she highlighted the differences between the manufacturing and construction sectors (i.e. scale complexity, durability, life span and function of its end user). Due to these similarities and the project driven environment of the construction industry it is clear that an innovation journey model for construction has the potential to be very different from the model proposed by Van de Ven et al (2000). Although Tidd et al aimed to criticise Van de Ven et al's model, it would be potentially beneficial to gain a similar level of understanding of the journey an innovation takes within a project based industry such as construction.

A lot of the criticism that has been made regarding the display of innovation as a process, centres on the fact that to display a model as a linear sequence is to neglect elements of feedback within the system. Indeed, it would appear that this is perhaps where the focus of Francis's (2000) concerns relating to the use of well-constructed stages and phases to depict innovation as a process emanated from. Francis (2000) cited Senge (1992) who argued that without the use of a feedback loop the innovation process becomes mechanistic and repetitive. This consideration is relevant as it is possible to see many linear models now existing with feedback loops implied within the process thus allowing the management to have the ability to be reflective and adjust the process to suit the innovations requirements. Indeed Francis's (2000) model included a feedback loop for each of the stages of his linear model. Such a display has been taken a step further by the likes of Rosegger (1980) who view the innovation as acting as a process that is represented as a cycle containing feedback at the end of its phases. Rosegger argues that the linear progression model fails to account for the way in which decisions affect each other within the process of innovation. The idea that the lessons of each stage are fed back into the system, allows the innovation process to include the reflective capacity to learn. Indeed some representations such as West (1990) have gone further and have displayed the innovation process as operating as a number of phases that form a complete cycle, emphasising total reflection and feedback within the process.

Viewing the innovation as a cycle has the potential to mistakenly interpret it as a closed process simply drawing on learning from the previous cycle. There is a need to view each process as a separate entity (particularly in construction due to the unique nature of the projects) requiring its own management based within the context of the situation.

However, the view of the cycle is relevant for emphasising the need for a reflective process that aims to improve over its lifecycle. This capacity is not represented effectively within the emergent model nor within the product development based models of for example Cooper (2001).

This sub section has outlined the four principle formats and styles to which innovation is represented. An understanding of the four modelling formats is necessary when assessing case studies. However, current research thinking relating to trying to understand innovation is identifying a requirement to consider using different methods of representation of an innovation, as this provides differing interpretations of the same empirical example. Research suggests that different styles or formats of models complement each other and should not be disregarded as they have the potential to assist our knowledge of innovation within a context from a number of different empirical standpoints.

2.3.3 Success factors for managing innovation

The previous section of the review focused on the conceptual frameworks of modelling innovation. The focus of this discussion was to identify the theoretical foundations from which researchers have tried to understand the nature of the innovation process for the benefits of improving its management. Such models are traditionally produced in tandem with the development of management success factors for the process. This section will discuss some of the management success factors developed within general management modelling, prior to considering construction innovation within the following sections.

Van de Ven (1986) identified four main types of problems that are traditionally encountered within the innovation process as being 1) human problems (managing change, resistance), 2) process problems (converting new ideas into profitable operations), 3) strategic problems (leadership transition, knowledge management), and 4) structural problems (management relationships between functions). Zain (1995) also highlighted four main types of problems facing the innovation process as 1) knowledge problems (knowledge management, leadership and communication) 2) general problems (human problems i.e. resistance, cultural issues and structural integration etc), 3) technical problems (integration with existing processes and knowledge issues) and 4) market problems (suitability to market needs, market changes). It is possible to see the linkages between both of the sets of factors, as conceptually both are describing the same set of conceptual factors but placing them into a different framework. This pattern is noted throughout innovation research and it can be argued that the frameworks adopted reflect to some extent the empirical focus of the research. Some success factors for example will be split into a high degree of detail, i.e. Cooper (2001) for example, and some like Dooley and O'Sullivan (2000) will use much broader categories as their framework. Regardless of the structure of the framework there are several common themes that emerge that are worthy of consideration. This review will group the success factors into three broader categories 1) strategic, 2) structural and 3) cultural issues, which can be used as a framework for discussion.

The strategic success factors commonly relate to the concerns of the organisation and the need to ensure that the innovation is integrated within its needs and requirements. This is reflected by the organisational focus of the general management knowledge existing on the innovation process. Tidd et al (2003) argues that innovation processes need to form a strategic perspective to ensure a) an appropriate structure, b) provide an effective vision for the future and c) to ensure that the organisation creates a learning culture. Cooper (2001) highlights the need for the effective interaction of the product (innovation) within the market and produced an array of factors that aim to facilitate this. The need of the organisation to have strategic awareness with the market is important to the innovations success within this context. Rothwell and Zegveld (1985) on the other hand view an organisation's strategic responsibility concerning innovation as relating to being effective and careful in the choice of innovation for the needs of the market, and to ensure that it is connected to the long-term needs of the organisation. These understandings tie in with the observations made by Jones and Saad (2003) in their assessment of success factors for construction innovation (with regards to an organisational focus). They called for innovation to be treated as a corporate wide task, to adopt a strategic approach to its management and ensure that sufficient top-level management is involved to reduce the risk. They placed emphasis on the need for construction organisations to achieve good linkages with other organisations and to ensure that they satisfy the needs of the market. Although the understanding of the strategic factors is predominantly gained from an organisational perspective, there is a case for suggesting that projects will experience a similar set of strategic management success factors.

The structural success factors relate to the nature of the innovation process itself and to how management should structure their interaction with the process. Cooper (2001) identified the need for an organisation's top management to support the process, the need to monitor and resource the process, and the need to conduct regular decision points by which the process can be controlled. He stresses the need to structure the process in a manner that management and employees are involved and develop a sense of empowerment. These themes are common within other research by the likes of Rothwell and Zegveld (1985), Dooley and O'Sullivan (2000) and Francis (2000) as they addressed factors such as ensuring the process received sufficient leadership, support, involvement from top-level management, in addition to the high levels of empowerment and involvement of the remainder of the workforce. Within the organisational context of general research, the structural success factors require both the physical structuring of checkpoints and monitoring procedures, as well as the cultural structuring of support and participation of those within the process. This is no different within the construction organisation as reflected by the factors identified by Jones and Saad (2003). Perhaps the one difference within the construction firm is the need to sustain the innovation, as although this will be a factor in any innovation process, within construction due to the nature of the environment (short-term focus, pressures on time, cost, and the constant requirement to change etc), the need to sustain the innovation is of greater significance.

Innovation research has clearly identified the cultural needs of the innovation process as requiring effective management to ensure the innovation's overall success. Many of the structural success factors call for the need for support and participation of those within the process. The cultural category takes the need to structure these activities, and develops and identifies the cultural needs of the innovation process. McCraw (1996) identifies that the underlying common denominator for effective management of innovation was people. Indeed Mayo (1933) and Trist et al (1963) (as cited by Dooley and O'Sullivan, 2000) argued that the human element of the organisation model was a critical factor. The success factors identified by the likes of Cooper (2001), Francis

(2000), Dooley and O'Sullivan (2000), Tidd et al (2003), Ahmed (1998) and Rothwell and Zegveld (1985) relate to providing the correct environment within which to innovate and then support that innovation. They identified the need for the correct balance between leadership and empowerment to be struck within the process. The cultural environment of the organisation is regarded as vital to the success of the innovation and it is recognised that for a successful innovation the organisation has to support innovation through the establishment of characteristics in its nature such as being i.e. creative, learning, open, flexible, willingness to take new ideas, accepting, etc. The cultural importance to a team of having clarity of goals for innovation, and a high degree of understanding is emphasised within the success factors illustrated, and a range of techniques has been outlined in the literature as a means to achieving this. An organisation that can strike the right cultural balance and achieve an informal atmosphere from a social point of view within the workforce, whilst achieving the rigour and formal structuring of monitoring and leadership of the process will clearly be successful within the innovation process. This is an understanding also observed by Jones and Saad (2003) who emphasised the importance of increasing the acceptance within teams for innovations through facilitation techniques such as the use of innovation champions within the organisation responsible for pushing the process.

2.3.4 Summary of section

This section reviewed the theoretical framework from which the innovation process has been modelled and understood within general management. This review concluded that there is no such thing as a wrong innovation model within research, but that each model represents an abstraction of the purpose of the research and of the specific context investigated. It is necessary to observe therefore that when modelling innovation that it is representative of the realities of the context to which it exists, in order that the management requirements are tailored to the specifics of this situation. The section observed that the analysis of innovation is best achieved using a multiple analysis approach as suggested by Baskerville and Pries- Heje (2001). As a result, when assessing innovation within the context of construction, there is a need to ground this understanding within the realities of this environment.

2.4 Context of construction innovation

The existence of low levels of innovation has been an acknowledged phenomenon within construction for over 40 years (McCraw, 1996). This identification traditionally did not trouble many within the industry as they regarded innovation as a low priority for a mature traditional industry such as construction (Pries and Janszen (1995). However, in the past 10- 15 years the significance of low innovation levels has been recognised through its identification as a negative influence on wider problems such as productivity, quality and the increasing difficulties in project management facing the industry (Mitropoulos and Tatum, 2000). Concern has emerged that the current levels of innovation occurring within organisations and projects has the capacity to severely harm the long- term potential and sustainability of the industry (Nam and Tatum, 1989). McCraw (1996) argues that the negative consequences of low innovation levels within construction has become exacerbated in the last 10- 15 years due to the industry's inability to adjust to the ever- changing environment of modern business. Gann (2000) and Nam and Tatum (1989) have cited the low levels as a symptom of an industry that has failed to acknowledge and adapt to the needs of the market and change in its practices. Seaden (1996) directly connects low innovation levels with the technologically less than optimal product that construction presently offers to its market. These low levels feature as concerns within reports such as Egan (1998) and Fairclough (2002) that acknowledge the need to break away from time- honoured traditions (Forbes, 2001) and embrace the ever changing environment in which modern businesses operate (McCraw, 1996). This need to improve the levels of innovation within construction has been representative of the wider agenda of 'rethinking' the nature of construction, to address the wider competitiveness problems.

Increasingly industry observers are making the connection between market success and the need for continuous improvement and innovation (Forbes, 2001, Beck, 2001). The likes of Kanter (1983) and Tidd et al (1998) highlight the use of innovation as a tool for both strategic and competitive advantage as representing the cornerstone of any progressive innovative organisation regardless of economic sector. Kanter ties organisational success directly with its ability to master its interaction with the flexibility and adaptability required within the market place, and regards innovation as the key strategic tool for achieving this. Academics like Flannagan (1999) suggest that constructions failure to assign similar value to innovation as a strategic tool stems from the false belief among many that construction suffers from a unique set of problems and factors as a sector.

Pries and Janszen (1995) argue that construction needs to operate in a more extrovert and market- driven way, and that it must move to reconsider its capabilities as a result. Forbes (2001) adds to this by arguing that the construction market requires the industry to be more flexible and adaptable to the constantly changing conditions within which it operates. McCraw (1996) observes that market desire now drives innovation thinking within construction, strengthening the call for construction to adopt a proactive stance with regard to the importance of innovation in satisfying market demands. Slaughter (1998) highlighted that innovation within construction had clear benefits with relation to economic growth (citing Schumpeter, 1934), increases in productivity (citing Schmookler, 1952), market growth, and reduced cost of production, and increase in technological feasibility, as well as the wider societal benefits that it can bring. Egan (1998) has argued that these are the improvements of necessity for construction and stressed the value of innovation as a method for aiding their achievement.

Langford (2000) argues that the construction market has changed over the last 40 years from a market representing stability and relative predictability to one of increased competition increasingly global (McCraw, 1996) and the demands for flexibility and value from its customers. This shift towards the dominance of the client has resulted in an industry that increasingly focuses on and has felt constrained principally by the considerations of budgets and schedules. Construction has reacted to this change in market conditions by regarding innovation as an activity that is placed on the backburner as it learns to engage more effectively with its new environment. Slaughter (1998) states that a significant reason for such a reaction has stemmed from the 'intangible nature of the benefits of innovation, as they tend to appear in forms that are not initially evident (i.e. quantifiable income or savings), but rather appear in terms of improved reputation, ease of work and the attraction of promising new hires'.

The identification of the importance of innovation as a tool for construction to effectively interact with the demands of the market, has led to claims that it is the structure of the industry, along with the traditional management style of the construction organisation that is hindering innovation (Pries and Janszen, 1995). Indeed Koskela and

Vrijhoef (2001) stress that our theoretical understanding of construction has not allowed the industry to recognise the need for innovation, and also highlights this as an explanation for the industries inability to transfer innovations from manufacturing on a theoretical level, such as lean. There is a growing realisation within construction that the industry needs to change in terms of structure and as organisations towards a 'modern industrial enterprise' (under Chandler's criteria, cited by Koskela and Vrijhoef (2001)) by being more flexible and adaptable to changes within the market. This realisation is slowly being embraced by the construction industry, as it considers how to become less dominated with strategies of mere survival and move towards a focus on the long- term sustainability of construction as an industry.

Over the last decade much of the research relating to innovation within construction has attempted to ask the question, how and why a situation such as this has occurred and been allowed to develop almost without corrective action being taken? An important observation has been made by academics such as Nam and Tatum (1989), Mitropoulos and Tatum (1999, 2000), Gann (2001) and Winch (2000) as they suggest that the low levels of innovation within construction is not related to the levels of idea creation within the industry, but are rooted in the industries inability to effectively adopt and utilise innovations whether they are process or technological in nature. It could be argued that although construction displays sufficient potential and opportunity within its mode of production for idea generation that it has failed to recognise the importance of managing the innovation process. Academics such as Pries and Janszen (1995) and Gann and Salter (2000) argue that culturally the lack of value or importance traditionally assigned within construction to the concept of innovation, has resulted in a general failure to recognise the management needs of innovation as a process.

Veshosky (1998) adds to this observation by stating that engineering and construction projects are inherently capable of problem- solving within unique conditions. Although distinct as concepts and requiring different management requirements under the definitions supplied in section 2.2 of the chapter, they share sufficient commonalities to ask the question why does the industry find innovation so difficult to manage? From observations such as this, it is possible to suggest that problem solving is recognised as an integral part of the construction process and therefore sufficient emphasis is placed on its management needs. However, this does not appear to be the case with regards to innovation. Pries and Janszen, (1995) illustrated that innovations within construction were restricted by a resistance and inability to diffuse innovations throughout the industry. These observations clearly identify the innovation problem as being predominantly a management problem as construction fails to harness its obvious potential for innovation effectively (Thomson and Munns, 2004). This review aims to ask the question why an industry created on an ethos of problem solving struggles to manage innovation and new ideas effectively?

2.5 Review of construction innovation

The identification that the innovation problem within construction is predominantly associated with its management provides a need to review the state and nature of the industry's approach to innovation. The previous section highlighted the industry's slow acceptance that innovation forms a key requirement for any successful enterprise and the growing appreciation within the industry that this also includes construction. Indeed the recognition of its importance is highlighted within both the Egan (1998) and Fairclough (2002) reports as forming one of the key strategic objectives of the rethinking agenda driving construction within the U.K. However, despite this increased awareness the problem of low innovation persists within the industry. This section will focus on three streams of thought within the literature that examine this problem further. These streams are 1) the scale of innovation, 2) understanding of the production process, and 3) a review of the direction that construction management as a sub-discipline has researched innovation.

2.5.1 Scale of innovation

Tidd et al (2003) defines the scale of an innovation as incremental (minor improvements to existing products, processes or systems) or radical (changes in the way we think about and use them). Koskela and Vrijhoef (2001) identified that construction needs not only to identify innovation as a strategic tool for achieving competitive advantage, but also required to adopt increasingly radical innovations. Beck (2001) strengthened this identification by claiming that construction needs to move from a culture dominated by attempts to find innovations that seek 5-10% improvements to one that should be seeking radical improvements in the order of 20-50%. He observed that those viewing the need for radical innovations as a problem confined to technological innovations, failed to recognise that the real problem relating to scale was not confined to specific types of innovation. He argued that it stemmed from a wider industry mindset and approach problem to being innovative that affects all types of innovations whether product, process, and service; or technological or management by nature.

It is possible to argue that such a culture stems from the traditions to which the construction market been perceived to reward the industry, i.e. seeking high levels of stability and low levels of uncertainty within the process (Jones and Saad, 2003). Gann

(1999) states that construction as an industry has aligned itself very much in this perspective and states that historically construction companies gained competitive advantage through the 'demonstration of competence.' The previous section acknowledged that whilst the demands of the construction market have evolved to increasingly recognise the need for innovation, it is clear that culturally the industry has been slower to adjust. This shift in the regard of the industry strategically for innovation has brought about a need to adjust the cultural approach of the industry towards both innovations generally, and the consideration of radical innovations.

Culturally innovation has been regarded as a risk that has the potential to threaten the stability and uncertainly levels within the process. This is a view that many within the industry have been slow to move away from, however there is evidence to suggest that this has not been helped by an increasing blame culture throughout the industry. For example Atkinson (1988) argues that there has evolved a culture within construction for clients to blame the defects of modern buildings on innovation. Although he argues that the evidence for such an assertion is not supporting of this, such a culture limits the desire of the construction industry to adopt a radical approach to innovation. Pries and Janzsen (1995) argued that due to the fragmented nature of the process and the uniqueness of each project any potential benefits of investing in innovations are difficult to quantify. The nature of this environment creates a culture of 'short- termism' that hinders the radical nature of innovation through the resultant lack of focus on long term planning (Chinowsky, 2001) and the absence of a learning culture (Riley et al, 2001). Coupled with the increased potential risks associated with radical innovations, culturally it can be difficult for the industry to assign need or incentive for radical innovation.

The existence of such a culture results in an industry where its members remain tied to incremental innovations predominantly within their own contribution to the process as this represents lower risk in addition to tangible benefits individually that can be taken from project to project. A failure within construction culturally to recognise the need for radical innovation with the objective of the longer term and greater good (as construction is retaining the individual approach to innovation), consequently restricts the ability to seek the scale of innovations required for the industry to improve. As a result, construction remains an industry that focuses on incremental innovations that responds to the need, as opposed to actively leading through the adoption of a radical approach (Gann, 2000).

2.5.2 Production process

The previous section of the review has outlined the cultural reluctance to accept innovation as a strategic tool within construction and the difficulties associated with culturally accepting radical innovations. However, there is a stream of thought emerging within the discipline that suggests that these problems are exasperated by a failure to understand how innovation as a concept interacts with the construction environment. This sub- section will assess two principle points, 1) the need to evolve our theoretical understanding of construction as a mode of production with regards to innovation in order to reflect the modern realities of the situation in practice; and 2) the need to base our understandings for managing innovation on the realities of construction as a mode of production and not on other industrial sectors such as manufacturing.

Koskela and Vrijhoef (2001) observed that the construction industry finds it difficult to identify and implement potential innovations, because the current theoretical understanding of its mode of production fails to allow for its recognition. They argue that the current understanding of the industries mode of production is outdated and not reflective of the realities in practice. Pries and Janszen (1995) contributes to this idea with the suggestion that construction fails to engage with the realties of the environment to which it exists. Both these academics identify that for an improvement to be achieved in the understanding and management of innovation within construction, there requires to be an improved understanding of the realties of the construction environment as a mode of production.

Jones and Saad (2003) argue that the industry is still coming to terms with the many changes that have occurred within the market over the last few decades as construction has been required to move from a fordist, to a post- fordist understanding of itself as a mode of production. The implications of a post- fordist viewpoint of construction demand an industry that is flexible, adaptive and responsive to the needs of the industry's clients, and places greater emphasis on the needs of the team (Smith, 2001). Jones and Saad (2003) recognise that such demands require construction to embrace innovation as a tool to assist the industry to meet the demands of this new environment, however Smith (2001) states that these demands actually encourage innovation also. They suggest that construction needs to develop a more sophisticated understanding of the needs of the post- fordist environment and its management implications on the implementation of innovation in order to maximise the potential benefits.

Koskela and Vrijhoef (2001) have been influential in arguing that the theoretical and practical understanding of construction is based traditionally on the transformational model of production. It is apparent that the post- fordist reality (Jones and Saad, 2003) does not adhere to this understanding and that whilst construction is slowly engaging with the changes connected with such a shift, Koskela and Vrijhoef (2001) argue that construction has remained tied to the transformational (fordist) model of the industry when considering innovation. They argue that innovation within construction has become increasingly difficult to manage as the understanding remains tied to a model that in reality does not exist and abstracts out uncertainty and interdependence. There is a need when managing an innovation process, for the nature of its interaction with the environment of implementation to be effectively understood. To base the management needs of the innovation process on an outdated perception of construction as a mode of production, fails to engage with the realities and needs of managing the process in practice. Koskela and Vrijhoef (2001) suggest that evidence illustrates that within such circumstances, the practical application of innovation has the potential to produce a process where its nature and management requirements are drastically different to what is expected. The failure to effectively implement the principles of lean within the construction context is an innovation that represents a good example of this problem. Koskela and Vrijhoef (2001) argued that this example highlights a failure to a) understand effectively the environment to which the innovation was being implemented and b) a failure to realise that construction is not a merely transformational production process more associated with fordist manufacturing principles.

With reference to the second point, Slaughter (1989) claims that a failure to acknowledge the need to engage with the realities of the construction environment with regards to managing innovation, originates also from the principles of innovation being founded and researched primarily on the manufacturing sectors of national economics. She argues that industry needs to acknowledge that there is a requirement to understand the practical realities of managing innovation within the construction context as opposed to those of other industrial sectors. Slaughter identifies that 'construction facilities are large, very complex and long lasting, and they are created and built by a temporary alliance of disparate organisations within an explicit social and political context'. She claimed that construction differed from manufacturing on 5 key factors that of 1) scale, 2) complexity, 3) longevity of use, 4) organisational context, and 5) social and political context. Pries and Jansen (1995) identified the fragmented nature of the process, the uniqueness of each project and the long life spans of the products as three factors that limited innovation within construction. Gann (2003) cited the work of Bowley (1960) who argued that the division between design and production, in addition to the industries structuring and organisation drastically restricted the potential for innovation. Slaughter (2001) argues that there is a need to understand that constructions environmental and structural factors have their own context to that of manufacturing, and that it is essential to understand how innovation exists within its own context during any implementation. Gann (2003) has criticised construction research for failing to achieve this, through to the predominance of research drawing on ideas from and comparisons with other industrial sectors. Koskela and Vrijhoef (1995) argue that the failure to understand how construction works in relation to innovation hinders top down innovation within the industry due to three factors none accounted for in the traditional thinking of the industry, 1) fragmentation, 2) myopic management and 3) inflated variability leading to deficiency in their adoption.

This is not to say that the problems within construction are unique from other sectors, but that they have contributed to an environment that is tied to an operational management approach to the process of its production. This operational approach has resulted in a culture of short termism and the need to ensure stability and low levels of uncertainty. Sexton and Barrett (2003) argued that such a culture has resulted in innovation constantly finding competition with the day-to-day environment and processes. It is difficult to achieve a culture that embraces change and innovation under such circumstances; however, this situation has not helped the apparent failure of construction to successfully implement innovations that it accepts as having potential. Failing to manage innovation generally costs money and time as well as threatening the stability of the construction process. As a result, there is a tendency to reject an innovative culture as it represents an unacceptable risk to the stability of the process (Sexton and Barrett, 2003). It is difficult to establish a culture of learning and acceptance of controlled risks within such an environment. It is clear that such an attitude can no longer continue, as the market is demanding innovation as a key component of the construction process (Chinowsky, 2001). Therefore, it is logical to argue that in order to achieve an acceptance of innovation, there needs to be a reduction in the risk involved in implementing innovations and an improvement in its management. This requires construction to begin to understand the relationship between innovation and its needs, and the processes of production.

Construction is a complex process of production, which differs from other sectors on many levels; however, it clearly shares many of the common principles of the modern business environment. It is possible to argue that to effectively satisfy this business environment there is a clear need to understand the nature of construction innovation in practice and how this integrates with this process, or how best it should manage the integration if it wishes to improve.

The nature of the integration of the innovation with the process of production within construction is vital to the success of its management. Hakansson and Johansson (1994) identified that construction's inability to integrate, 1) the actors involved, 2) the activities, 3) the resources, dramatically reduced the industry's ability to innovate. It can be argued that this stems largely from the industries failure to understand the requirements of an innovation within the context of the environment. Manufacturing has mastered the act of integrating the needs of innovation within the overall processes of the industry. Flannagan (1999) claims that construction differs from other sectors of the economy on three very important points- 1) its lack of integration, 2) its short-term relationships and 3) its separation of design and production. These are all key factors that inhibit integration of the industry's processes with the needs of innovation, especially when these needs are satisfied through the theoretical understandings of the manufacturing sector. It is possible from such observations to identify that construction will never be able to maximise its potential through innovation until it has effectively understood the manner to which innovation operates and its management requirements, and has been able to successfully integrate this within the processes of its modes of production. The failures of adopting innovations that are rooted both theoretically and in contexts that are not based in construction (i.e. management requirements based upon manufacturing based needs) or based on the false realties of construction are evident and prominently result in failure on this basis.

The following section will identify the direction and perspectives from which the innovation problem has been researched and considered within construction management, and aims to identify that there is a clear need to understand how innovation exists within construction in order to improve its management. There is a need to understand this from the perspective or viewpoint of the project environment to which it predominantly exists.

2.5.3 Innovation research within construction management- a review

Toole (2001) observed research within this area as aligning to two streams of thought, 1) construction innovation literature, and 2) diffusion of innovation literature. He classified his first stream (i.e. construction innovation literature) as composing of five sub- groups. It is possible to classify that three of his sub- groups are discussions assessing the barriers to innovation within the characteristics of organisations and projects, and the remaining two as attempts to understand what drives innovation thinking (i.e. the market or the technology). It is possible to conclude that the discussions relating to those groups associated with the barriers have tended to be focused on specific technologies or organisations, with very little scope for comparison with others due to the unique and specific nature of the research conducted. It is clear also that the second stream identified by Toole tends to be focused largely from an institutional/ strategic level, and on the whole therefore fails to engage with the problem of managing the implementation of innovations in practice.

Koskela and Vrijhoef (2001) identified three theoretical strands that guided and structured the research-taking place into innovation within construction. The authors acknowledge that due to the scarcity of theory and modelling relating to innovation within construction these categories are very general and all encompassing by their nature. Although illustrating similarities with the sub- groupings of Toole (2001), Koskela and Vrijhoef assess the literature from the perspective or viewpoint to which it was positioned, whereas Toole tends to focus categories more towards specific topic areas. This review prefers to adopt the Koskela and Vrijhoef (2001) approach due to its broader and more fluid form of categorisation. The authors observed that research into innovation within construction is split into strands by 1) its typology, and by the level of focus from which the research stems 2) an institutional viewpoint and 3) an organisational viewpoint. This section aims to trace the perspective to which research has focused on innovation within construction, with the aim of identifying that there has been a failure within research to understand and engage effectively with the problems of construction innovation. It will be suggested that this has occurred due to the disciplines lack of consideration of the project environment is which construction predominantly functions.

1) Typology

Koskela and Vrijhoef (2001) identify the use of the division of innovations by their type, as the dominant focus for research. Examples of this approach would be represented by the consideration within research projects of issues such as the problems associated with the use of partnering as an innovation within construction projects or the examination of the use of specific construction products in practice. This trend has been noted by Mitropoulos and Tatum (2000) as they criticised the industry for remaining tied to empirical examples of innovations (particularly when discussing failures and barriers), that illustrate experiences specific to that example and failing to add any new understanding to the general situation. This results in a failure to understand the generic processes taking place with innovation management and implementation, resulting in an understanding only stretching to the specifics of that particular type of innovation, and as a result, the comparison of processes and experiences is lost. The size and youthful nature of the discipline (Koskela and Vrijhoef, 2001), along with the reliance for funding and cooperation from the industry has been significantly responsible for the specific nature of much of the research.. It is possible to suggest that such specialisation on specific types and examples of innovation is driven by an overall lack of concern from the industry for the wider picture of innovation. This lack of coordination within the research community has resulted in a situation whereby little is known within construction as to how differing types of innovations relate to each other. The fragmented and specialised nature of the research exists mainly due to the absence of an agenda or a focus for the research's dissemination. This is an important area for understanding as only through an awareness of the differences and requirements of different innovations can we begin to effectively implement them within a multitude of different highly specialised environment factors.

Slaughter (2001) presents a type/ magnitude axis model that can be identified as providing a basis from which to develop a holistic viewpoint of the situation. A possible explanation for the neglect to define and identify innovations within construction prior to the likes of Slaughter (2001) can be argued to be rooted in the continued assessment of the industry's innovation situation from the perspective of manufacturing. She argued that much of the research concerning innovation within construction is based on examples of the manufacturing of products for the industry. Consequently, there remains a failure to assess innovation within the context of construction as a mode of production, as even although the products produced are for construction, the process of innovation remains tied to the principles and production methods of manufacturing. It is necessary to suggest the adoption of a holistic approach of the situation, as to focus the research findings on highly specialised and specific empirical examples fails to represent the situation as a whole, as well as neglecting to understand how innovation interacts within the context of the construction environment.

2) Institutional viewpoint

The second largest perspective from which construction management research has assessed innovation has been from an institutional viewpoint. Koskela and Vrijhoef (2001) highlighted this within the research of innovation as being, that which focuses on the structural and functional aspects of the industry that influence innovation. Van de Ven, Voordijk and Doree (2001) observed that the traditional analysis of the industry occurs at this level. Nam and Tatum (1989) identified that much of the recent concern relating to the low levels of innovation within construction has emanated largely from an institutional viewpoint i.e. government and industry observers. Government sponsored reports such as Latham (1994), Egan (1998) and Fairclough (2002) have been instrumental within the U.K. for identifying the necessity to address the levels of innovation and have provided the stimulus and funding necessary for academic and industrial research into the problem. A number of publications have followed within the U.K. with the likes of Winch (2000), Gann (1999), Print (1999), Salter et al (2000), and Pries and Janzsen (1995) representing examples of innovation research conducted at this level of discussion.

A wide array of research discussion areas have opened up within this focus, primarily relating to the need to rethink the perspective to which construction considers innovation with regard to the changing demands of the market. This perspective has been influential as construction attempts to understand its processes and the interaction this has with innovation. Examples such as McCraw (1996) and Chinowsky (2001) typify such an approach with their focus on innovations role in improving productivity, competitiveness and the need for market importance within the industry. The use of foresighting papers such as Flannagan (1999) are useful examples of the institutional viewpoint targeting the implications of innovation strategically on the industry. The likes of Nam and Tatum (1989), and Mitropoulos and Tatum (1999, 2000) have been key in highlighting how the dynamics of the industry act as barriers to the innovation process. This level of observation has been important in identifying industry dynamics such as its immobility, complexity, durability, costliness, and high degree of responsibility as acting as barriers to innovation (Nam and Tatum, 1989). Current research within this perspective has been influential in allowing regulations to be regarded as an opportunity for innovation culturally as opposed to a barrier (Gann, 1999). Academia has also questioned its own contribution to innovation through dissemination processes from this perspective (Print (1999), Slater et al (2000), Langford et al (2001) and Lorch (2000)).

The need to develop an improved understanding of the mechanisms of construction requires an effective contribution from this viewpoint of the industry, and can be seen in theoretical strands of construction management that target productivity, cost, time and project management. Innovation increasingly is recognised as a consideration of for all the lines of enquiry taken by research within construction management. Papers directly connecting innovation with the likes of decision- making (Todd, 1996), leadership (Nam and Tatum, 1997), teamwork (Pena- Mora and Harpoth, 2001) and communication pathways (Clarke, 1999) demonstrate this. This is a valuable step, but is restricted to an institutional viewpoint of the problem within the context of one empirical example or typology, as opposed to a broad investigation of the issue. Whilst this viewpoint is necessary for our understanding of innovation within construction, there is a need for an increase in the focus of innovation within the more practical levels of the industry.

3) Organisational viewpoint

Koskela and Vrijhoef (2001) identified a recently observed strand of research within construction that aimed to assess innovation within the context to which it exists in practice and that aimed to focus attention towards the role of organisations and firms within the innovation process. This clearly forms a necessary stream of discussion within the context of innovation research, as research from this perspective aims to investigate the actual complexities of the innovation process in practice. Although the role of the organisation has been considered within the institutional viewpoint, by focusing at the organisational level, the research acknowledges both the implementation phase of the innovation process, and the role the organisation plays within the successful management of the process. Sexton and Barrett (2003) identified the need for focus at this level, and observed that the interaction of an organisation with its environment differs with size, profoundly affecting its approach and management of innovation. Mitropoulos and Tatum (1999, 2000) highlighted the role of an organisation within the innovation process, by identifying an organisations culture and structure as significant in determining the creation, decision- making and implementation of an innovation. The likes of Kangari and Miyatake (1997) and White (2000) have been beneficial in providing evidence from construction firms both in the U.K. and in Japan that highlight the use of innovation for competitive advantage.

The flow of an innovation within an organisation is a consideration raised by Winch (1998, 2000) particularly with relation to its point of creation within the firm and the significant difference that this can make within its journey towards implementation. Winch modelled such flows under two categories, top- down innovations (created or identified by top- management) and bottom- up innovations (those that emanated from within the organisation). Winch identified that each type will experience different processes and routes towards implementation. Winch claimed that top- down innovation experienced barriers relating to a lack of incentives, the split role of systems integrators and a relative lack of demanding clients, which all act as factors that discourage the utilisation and implementation of innovations. Slaughter (1998) identified that due to the nature of the construction process, there is a largely untapped potential for innovation within the lowest levels of the hierarchy (i.e. those working on site), that requires such potential to be utilised through the removal of the barriers that often restrict the desire for and actual implementation of bottom- up innovation. This area of research demonstrates the value of investigating innovation within the context of its application within construction, something not possible with the strategic or specific focus on type discussed earlier.

Manufacturing has used the analysis of organisations as the arena for investigating the innovation process with particular focus on identifying the barriers and facilitating factors of influence (Poole and Van de Ven, 2000), and this is becoming a dominant area within construction as academia focuses on the process of innovation and change management (Jones and Saad, 2003). Due to the unique nature of most organisations, the discipline runs the risk of tackling such research in a similar manner to that of typology. This would result in empirical examples emerging of a very specialised and specific nature.

It is possible to argue that in the quest to understand how innovation interacts within the context of the construction environment in practice, that perhaps to limit the discussion to these three viewpoints would fail to acknowledge and understand innovation within the perspective to which it predominately operates as a mode of production, i.e. the project.

2.6 Innovation within the project environment

Gann and Salter (2000) identified the project environment as a neglected perspective of research for innovation within general management but specifically construction. Due to the industry's predominant reliance on the project as a mode of production, it is necessary therefore to understand innovation from within this perspective. Tatum (1984) called for innovation research within construction to assess the existence of innovation at the project level. This observation was made 20 years ago, and although construction research has developed and evolved along the three streams identified previously, there has been a failure to advance our understanding within the context of the realities of the project environment. Mitropoulos and Tatum (1999) have criticised present research as remaining specific in focus and at a high level, and argued that the discipline fails to address the wider generic problems of innovation implementation in practice due to the focus existing within principally the three perspectives. The emerging awareness of the strategic and cultural need for innovation within the construction 'organisation' and the apparent failure to assess innovation within the project environment, is symptomatic of a wider neglect within general management literature to assess innovation within the context of project- based industries, as identified by Gann and Salter (2000).

The growing understanding of innovation within the context of the construction 'organisation' has greatly assisted the understanding of the innovation within the context of construction. It has opened up the potential to understand the mechanisms and dynamics of the process of innovation, thereby allowing both the structural and cultural barriers to innovation to be understood within the firm environment. It is clear however that our understanding can never be complete until we assess the importance of the project environment, as this is predominantly the theatre to which the innovation is implemented. Within manufacturing the regard, for the 'project' will be conceptually different in relation to innovation due to the overall governance and culture, predominantly remaining associated with the organisation. Riley and Clare- Brown (2001) have been influential in identifying that within construction the culture is dominated by a 'project culture' and not by a 'company culture' as in manufacturing. It is clearly not appropriate to retain the innovation discussion at the practical levels to that of the organisation in the manner that manufacturing research has. There is enough potential to suggest that the construction project operates and is influenced with its own context.

Gann and Salter (2000) argue that the project- based character of construction, due to both the discontinuous and temporary nature of projects, and the poor linkages existing between project and business processes, creates problems for the speed of the assimilation of new ideas. Whyte et al (2002) argues that the adversarial culture and fragmentation of the different participants in most construction projects and the engineer's paradigm (short-term focus) combine to greatly affect innovation within the project environment. Pries and Janszen (1995) draw attention to the segmented nature of the building process as providing a major problem for innovation within this context, along with the separation of the design and production phases of the process, and the uniqueness of each project. They argued that because of the cultural implications of such an environment within the project, there existed little incentive for contractors to invest in the process as the economies of scale did not support the learning effects.

The role of project management as defined by Winch (2001) is 'for a process of the progressive reduction of uncertainty through time'. The need for stability and reduced uncertainty as a process is not assisted by factors existing within the construction project environment such as being location bound, having a long life span, and high costs. Pries and Janszen (1995) argue that this background results in clients retaining proven methods, having a low desire for trialability, low levels of co- ownership (due to high frequency of SME's and their varying contribution). Jones and Saad (2003) have been influential in suggesting that it is little wonder that project management within construction culturally is regarded as adverse to innovation when the definition in the British Standards presents a strong fordist understanding of the concept. The standard emphasises the need for reduced uncertainty and risk within the process providing a cultural understanding that can be perceived to reject innovation.

The project within construction takes the format of an operational approach (Pries and Janszen, 1995) and fails to employ any strategic management characteristics. This can be highlighted by both the failure of contractors to look beyond the horizon of the end of the project (i.e. their poor record on disseminating innovation between projects

(Langford et al, 2001)), and the poor communication pathways existing both within the project and between the project and the participating organisations (Veshoshy, 1998). It is clear that the nature of the construction process and the structural influences placed on the process of construction, not only restrict innovation potential themselves, but also create a culture that inhibits any desire to innovate. Gann (2000) argues that there is a need to balance the soft general interacting skills with the hard speciality technical skills, as this is the only way to enable effective integration and the use of complex technologies within interdisciplinary teams. It is clear that the management of the innovation process can be greatly improved through both a better understanding of the structural implications of construction within the project environment, and an equally significant assessment of the cultural requirements of innovation within the project environment. The nature of decision- making (Laufer, Woodward and Howell, 1999), communication pathways (Veshoshy, 1998), leadership confusion (Pries and Janszen, 1995), knowledge management (Egbu et al, 2001) and supply chain relations (Kumaraswamy, 2000) clearly all impact on the ability to manage innovation within the construction project environment.

Keegan and Turner (2003) concluded that project- based firms generally stifle innovation through the very project control systems around which the firms operate. As a result there exists a culture where there is little tolerance of slack resources, and a struggle to see the 'universal usefulness of innovation due to their focus on cost and risk' (Keegan and Turner, 2003). They argue 'that the integration of the project and the innovation is still dominated by how to correctly manage projects as opposed to effectively managing innovation'. It is possible to conclude that as a result there is a definite need to understand the innovation problem within the project environment as it appears to be a particularly hostile environment to innovate and far more complex than any of the other perspectives would allow for appreciation.

During this chapter, the need to understand the integration of innovation and construction has been identified, and it is logical to call for an assessment of the integration of innovation within the environment discussed within this section. Winch (2000) has been influential in making such assessments through his identification of the differences between an innovative and non-innovative project within construction. He argues that an innovative project will demonstrate characteristics of a flat organisation, ambiguous and overlapping role of responsibilities, reliance upon strong leaders of coordination of work, and enjoy a high commitment to work and colleagues. This contrasts to the tall hierarchy, clear division of labour and precise definitions of roles, reliance upon procedures for the co- ordination of work, and a low commitment to work and colleagues, presently evident in many construction projects (Winch, 2000). It is clear that what the likes of Winch (2000) and Gann (2000) want to develop is for construction projects to adopt characteristics structurally and culturally common within organisations with a view to lessening the problems created by the projects temporary existence. It is possible to argue that what they demand is a project that is managed both structurally and culturally in line with the demands of the industry (post- fordist demands, Jones and Saad (2003)) and to take on some of the characteristics of 'modern businesses' under Chandler's definition. This is very difficult to achieve and will take generations, but it is clear that for innovation to improve within the project environment there needs to be an understanding of how to improve both the structural and cultural factors affecting this process. The organisational approach to the study of innovation has identified a firm's internal environment as a significant area for research with reference to innovation, however it is perhaps more appropriate to assess the internal environment (i.e. culture and structure) of the construction project in relation to innovation.

2.7 Models of construction innovation

This chapter has considered in detail the role of modelling innovation within general management research as a tool for assisting in the understanding of the concept. This section will review attempts within construction management research to model innovation.

Slaughter (1998) divided models of innovation within construction as being displayed and organised in two principles, the magnitude of change from existing practice, and the expected linkages of the innovation to other components and systems. She identified five types of model, incremental and radial types that focused on the magnitude of the innovation, modular and architectural types that represent the degree of interaction with other components or systems, and system innovations that represent the linkages between the innovation and the context. Assessing innovation within these contexts is useful as it emphasises the innovation and its relationship with the environment to which it is acting upon. She argues that by placing innovation into one of the five categories provides the opportunity to predict the degree of change and for planning the type of activities and resources necessary to effectively implement the innovation. This is a useful contribution to the understanding of innovation within the context of construction; however, Slaughter suggests that it is possible to place the 5 types on an axis of magnitude representing the degree of change. This in reality is difficult as it is possible to have a radical innovation that requires very little change to its linkages to its context. There is no room in her scale to accommodate the difference this may represent compared to incremental innovation that represents considerable change to its linkages to the context. Despite this, the realisation that the management of an innovation can vary due to the nature of the context to which it is occurring is important. Slaughter fails however, to develop the idea specifically within the project context empirically; although she does recognise the importance of the context of innovation.

Jones and Saad (2003) considered innovation within the context of construction and shared the concerns of presenting a linear process model, as they felt the tendency of such an approach increased the risks in oversimplifying the process of innovation. They argue that the phases of the process when observed in practice, experience a blurring of their boundaries and that their order may vary in a fluid manner. These concerns have been discussed in the previous sections relating to general management research; however, Jones and Saad align their understanding of modelling the innovation process in line with the Rosegger (1980) model or the cycle model commonly presented. They identified a model that was more systematic in approach and proposed a model divided in 5 stages, identification of the need to innovate, knowledge awareness, choice, planning and implementation. They advocated the use of such a model as a tool to attempt to develop an in- depth understanding of the mechanisms by which key stages of innovation can be effectively shaped and managed. They highlight the lengthy, complex and dynamic process requiring a systematic approach to management of these key stages. These observations tie in with the discussions on the conceptual framework for modelling innovation discussed previously, however it is clear that much of Jones and Saad (2003) understandings of the innovation process are directed towards the strategic and organisational perspectives of the construction industry. This focus is very influential in identifying many of the barriers towards innovation, with considerable work conducted into understanding how the dynamics of the industry make the process of innovation difficult.

Jones and Saad are conscious of the impact that the project environment of construction plays on the management of innovation, and have identified the dynamics and complexities of this environment as particular barriers. However, it can be concluded that they remain tied in their understandings of the innovation within the project environment from the perspective of the organisation. This is not a criticism of their approach but although they have identified innovation as being problematic within this environment, they have not developed a model for innovation from this perspective. Jones and Saad (2003) are good examples of Koskela and Vrijhoef's (2001) observation that innovation has been tied predominantly to type, institutional and organisational viewpoints. Jones and Saad (2003) focused on partnering as an innovation and their approach to this presented an example of Koskela's observation as being specific to this type of innovation.

Construction projects are unique, complex and dynamic environments in which to manage an innovation process (Gann and Salter, 2000). Current construction innovation thinking is beginning to appreciate the need for focusing on the project environment, although this focus has remained from an institutional or organisational perspective with a useful example being the work of Jones and Saad (2003). The importance of Slaughter (1998) in highlighting the need to understand not only the scale of the innovation, but also the impact on the linkages between the innovation and the context, highlights the need to understand the dynamics of the innovation process from the project perspective in which it operates. It is necessary to develop a model that allows an understanding of the innovation process within this context, and to assess the management requirements to enable the innovation to effectively integrate with the project environment in which it finds itself. The importance of understanding how an innovation integrates with the context to which it is occurring could be argued to be the key to understanding how to effectively manage the innovation process. Understanding the impact the project environment has on the innovation and the impact that the innovation has on the project environment is essential for effective integration and therefore management of the innovation process.

Kagiologlou et al (2002) argued that the only manner to effectively understand a process is through the technique of process mapping. They conducted work into mapping the production process of construction, and identified that many innovations within the industry have been connected to improving the process of production. They concluded that there is a need therefore for a greater understanding of the realties of the situation. This observation strengthens the case made within the review for trying to understand the innovation process through the use of modelling techniques based within the empirical context of the project environment, as only through this can we begin to understand the realities of the problems at this level.

2.8 Success factors for managing innovation within construction

Although research relating to the success factors for managing innovation within construction has been limited, much of the empirical discussion relating to this issue tends to be dominated by the cultural attributes of the process. The dominance of cultural success factors as opposed to either strategic or structural factors reflects the perception within the industry of where the problem lies. McCraw (1996) for example argues that to improve innovation levels within construction there requires to be a cultural transformation. Yean Yng Ling (2003) observed that the two most significant factors for successful innovation were if it was perceived to be of benefit, and if there existed a conducive working environment. Indeed much of the discussion relating to the problems of managing the innovation process within construction is connected to issues such as trust and empowerment (Rapp, 2001). Rankin (1998) argues that trust is essential within a process to ensure successful business results. His focus is within the financial sector; however, research within construction places the same emphasis on such concepts. Fairholm and Fairholm (1999) emphasis the significance of leadership and trust as essential for achieving successful innovation management. The relationship between effective leadership and the level of trust an individual has for an innovation, is important. Nam and Tatum (1997) identified the role of leaders and innovation champions as necessary for achieving successful innovation within construction. The need for leadership to facilitate the acceptance levels of the team in order that they trust and understand the innovation is a key consideration for successful management.

It is apparent that the management of the innovation process requires to effectively establish a culture, through both structural and cultural mechanisms that allow those involved in the process to understand, accept, feel involved (empowered), trust, and feel motivated to contribute to the success of the process. Many of the aspects highlighted within the construction management literature relating to innovation targets elements of this need. Egbu (2004) identified many of these aspects as core competencies vital for organisational innovations, observing the significance of their satisfaction in the creation of a culture and structure for the exchange of knowledge, observed as necessary for managing innovation. The innovation process requires careful management to ensure its success, and the likes of Sutton (2002) have highlighted the need for such management to ensure that the process is controlled. This point could be argued to be a structural success factor; however, it is primarily its implications for the cultural aspects of the innovation process that concerned the likes of Sutton (2002). A controlled process takes away the dangers of raw enthusiasm and maximises the potential benefits that innovation can bring. To maximise the control that management have over a process there is a requirement to develop an understanding of the nature of the process and therefore develop a series of success factors for its management. However, it is clear that research into this area remains limited and factors that are identified are predominantly the consequence of research into broad management concepts such as leadership, trust and communication where their relevance to innovation is one of many issues and not the focus of the research.

Dooley and O'Sullivan (2000), when assessing general innovation management, advocated that there is a need to provide and identify a number of enablers that allows the process to be effective. It is necessary to establish what these pillars or management success factors are within the context of innovation management within the construction project environment, to ensure that the strategic, structural and cultural attributes of the innovation process are facilitated adequately. The modelling of innovation within construction remains tied to empirical strands of focus, particularly within the project environment. As a result, there is a need to understand and establish success factors within the project environment regarding the management of innovation.

The failure to develop success factors for the management of innovation within construction projects is unusual when considering the amount of research existing on project management. Clarke (1999) identifies four success factors critical to project management within construction, communication throughout the project, clear objectives and scope, breaking the project into 'bit sized chunks', and using project plans as working documents. These factors represent many of the requirements necessary to achieve a successful innovation within the environment. It is necessary therefore to focus on innovation processes within this environment and perhaps to begin to target innovation as a process requiring to be understood in the same way the industry attempts to understand the wider problem of project management.

2.9 Summary of the literature review

This review has highlighted the need for construction to embrace innovation as a strategic tool to aid necessary improvements required in performance and the industries ability to interact with the ever-changing requirements of its market. Nam and Tatum (1989) cited the low levels of innovation within the construction process as potentially threatening the long- term sustainability of the industry. The review identified construction as a process with enormous potential for idea generation and creativity, but that it failed to transform this resource effectively into successful innovations. There is a need therefore to understand why an industry that is dominated as a mode of production largely based on the principles and processes of problem- solving struggles, to effectively manage the process of innovation.

The review identified that there is a need to understand innovation within construction and to achieve this effectively the concept requires to be regarded as, a) a process requiring management throughout its lifecycle, and b) requiring to be assessed from the perspective to which construction operates predominantly as a mode of production, the project environment. As a discipline, there has been a neglect to assess innovation within these contexts, resulting in a failure to effectively understand the innovation process within the realities of the construction environment.

The use of modelling is identified within the review as the principle technique used within general management research for developing such an understanding of the innovation processes. The framework for modelling an innovation process is outlined within this chapter highlighting the use of this technique for understanding both a) the theoretical existence of the concept and b) for allowing the production of a greater understanding of the practical implications and management needs of the process. An understanding of both these aspects has failed to emerge within construction that is rooted within the context and specifics of its project environment.

This chapter identified that construction has yet to fully understand conceptually the nature and dynamics of the existence of innovation within this context, and how it interacts with the industries mode of production in practice. Only through the further development of an understanding of the dynamics of this interaction can the process be effectively understood, thus allowing for appropriate management strategies to be devised. As a result, the research will aim to focus on understanding the innovation process at both a theoretical and practical level. The following chapter will outline the existence of innovation within the construction project environment and provide a brief description of the research and its objectives.

Chapter 3

3 Innovation within the project environment

3.1 Introduction

This chapter aims to draw on the concepts and observations identified within the literature review, and logically construct a framework for a research project capable of adding to and advancing the existing knowledge base relating to construction innovation. The discussion is split into two sections, firstly outlining of the nature of innovation within the construction project environment, through the identification of attributes for both the innovation and the project. This aims to provide a set of attributes where by an understanding can be developed and tailored to the needs and requirements of the realities of the environmental context. This leads into the second point which is a description of the main aim and objectives of the research.

3.2 The nature of innovation in a project environment

When considering the task of modelling an innovation within the construction project environment it is necessary to recognise that the industry and particularly the project nature of its mode of production results in an innovation process that potentially operates under differing influences (Koskela and Vrijhoef, 2001), and with different requirements than other sectors of the economy (Jones and Saad, 2003). This section identifies three aspects that require to be observed in order to effectively model innovation within this context, 1) to understand and model the innovation process within the realities of the construction project environment, thus ensuring that it is not influenced by understandings of innovation rooted from other economic sectors. In doing this, it will outline both 2) the existence of innovation within the project environment, and 3) the project variables that influence the innovation process. A set of attributes is outlined to enable the variations of both the innovation and the project to be observed and considered. This will provide a foundation from which to understand the context of managing the innovation process. The discussion will outline the different form of each attribute, with the objective of examining their effect and implications on the management of the innovation process within the research.

3.2.1 The realities of the environment

The literature review highlighted many of the differences between the environment of a construction project and that of manufacturing, with particular reference to the product development model of innovation produced by the likes of Utterback (1994). Recognition was established that an approach was required that reflected the realities and complexities of the construction project environment. Such an approach allows the development of an understanding and model of the innovation process that is reflective of this environment, thus ensuring that it is not influenced falsely by understandings of innovation rooted from other economic sectors such as manufacturing.

The review has highlighted the differing approach that construction has to innovation with regard to its perspective to the market, and this has resulted in a differing psychology within the innovation process relating to idea creation and the creativity aspects of the concept. A manufacturing organisation requires to be creative in order to achieve market success; however, within construction, project creativity stems much more from necessity and is more spontaneous in its nature. Consequently, the focus of the concept differs slightly, as does the management requirements for the process. It is possible to argue that a construction project is less dominated by the creativity component of the innovation process than manufacturing as a process, as within construction, this predominantly is created elsewhere. This is an example of one of the aspects of managing innovation within the construction project environment that differs from the manufacturing context, and indicates the need to develop a model rooted in the context of the construction project as opposed to borrowing or adapting a model based on a differing context. The context of the process will affect the emphasis on creativity, and the overall management of the process within the environment to which it finds itself.

Understanding the realities of managing innovation within the construction project environment requires the establishment of both the nature and variations of innovation that exist within this context, and the variations within construction projects that can influence the innovation process, in order to reflect the realities in practice. Construction projects are unique by their nature and a common framework is required from which understanding and modelling of the innovation process can develop. Establishing a set of attributes for both the innovation and the project provides a framework for comparisons between projects and for the development of generic theories of the innovation process within such an environment. The following two sections outline the exiting literature within general management and construction relating to these two issues, prior to developing and identifying the differing nature that exists in each area.

3.2.2 The nature of innovation

Construction management has increasingly recognised the significance of understanding the conceptual nature of innovation within the industry. Slaughter (1998) has been influential in the development of this understanding by providing definitions for the form of the innovation attributes within the construction industry. She points within her definition of innovation towards two principle attributes that characterise the concept, stating that innovation exists largely in the form of a product, a process or as a system, and emphasises that innovation requires to be nontrivial to the form of implementation. By outlining such concepts within her definitions, she suggests two axes of complexity differentiating the attributes in order to define the form of the innovation, i.e. through type and scale.

Slaughter's identification ties in with general management research by the likes of Totterdell et al (2002) who identified that innovation requires to be understood by both its type and characteristics. Totterdell et al's use of the term characteristics suggests that they feel that innovation exists displaying other attributes than simply scale. Their work into organisational innovation identified that research had provided a lack of attention given to the types and characteristics of innovations. Whilst construction management has focused increasingly on this issue through the likes of Slaughter (1998), there remains a lack of attention at the project level, where the need for such a focus at this level is emphasised by Totterdell et al's identification that the environment determines the form of the type and characteristics of innovation. It is logical therefore to suggest that an understanding of the form of the different types and characteristics of innovation within the construction project environment requires development. In addition, Totterdell et al observed that different types of innovation or innovations possessing contrasting characteristics will have a distinct impact on the consequences of innovation. This observation emerged within the context of organisational research; however, the same principles will apply within other contexts such as the project environment within construction. It is necessary therefore to not only identify the form of the type and characteristics of innovation within this environment, but to also ask the question of whether their differences require different management considerations. These are questions asked in other fields by the likes of Zaltman and Wallendorf (1983) and Damanpour (1987), and it is necessary within this context.

The common attributes identified for innovation has been to assess it by its type, scale and with relation to its source of origin. The likes of Tidd et al (2003) and Burns and Stalker (1995) have commonly followed this set of attributes. They argue that individual innovations require to be tailored in a management sense, depending on the nature of the organisation and the attributes of the innovation. Understanding the attributes that an innovation possesses under Totterdell et al's (2000) assertion would allow for an increase in the effectiveness of its implementation. This is particularly relevant to the management of innovation within this context due to the individually unique nature of the project environment.

This research will adopt the common approach identified by Tidd et al (2003) and Burns and Stalker (1995) and suggest that innovation exits within the construction project environment in three attributes, type, scale and source. As a set of attributes, they are sufficiently generic to be applied to any innovation; however, both their form and implications require to be outlined within this context.

1) Type of innovation

Innovation traditionally has been understood as split into types of either product or process. This sub- section will outline the difficulty of using the term product and process within the construction project context and present three innovation types requiring consideration, system, process and component. Each will be outlined, highlighting their differing relationship between the innovation and the project.

Product and Process Innovations

The foundations of innovation research are based on the distinction between product and process innovation within the context of either the manufacturing or organisation due to their predominance empirically. Within these environments it is easy to define a product innovation as existing as an innovative output of the mode of the production process. Organisations such as General Motors will continually want to innovate their product (i.e. cars) in an attempt to achieve a better product for offering to the market. For a bank such as the Royal Bank of Scotland a product innovation could represent an innovation to a mortgage package that they offer. This package is required to compete with other banks in the market place and innovation of such packages is a valued method of achieving success within this context. The form of the innovation and the relevant management requirements follow those laid out in the product development models of for example Cooper (2001). The process innovation on the other hand refers to innovation in the mode of production itself. Within manufacturing, this is represented by innovations that take place into the sequence of operations that achieve the end product. There is no requirement for the process innovation to affect the nature of the end product, although the two are often interdependent. Process innovations are innovations in the manner that things are done, whether they are technological or management related (Tidd et al, 2003). Utterback (1994) was influential in addressing the need to regard both of these types as occurring in different manners and stages of development within an organisational lifecycle, and observed therefore that they require different management considerations.

Within the context of the construction 'organisation', it is possible to discuss innovation as existing in similar terms. However, it is apparent that part of the difficulty with managing innovation within construction is that there exists a need for a more developed understanding of this attribute that is reflective of the construction project. The traditional understanding of product innovation is that it is producer led. This is apparent within manufacturing firms and is evident within the context of construction organisations; however, it becomes inappropriate with regard to the construction project. This research argues that the construction project is by comparison client led, in that its demand stems from a specific need identified to the project team by the client (Gann, 2003). Whereas a construction organisation can pursue a product innovation through its presentation to market in a speculative manner (i.e. a type of housing package), the construction project due to its nature remains reactive to the needs of the client. This changes the dynamics of our understanding behind the concept of product and makes it a difficult term to use when referring to the 'end product' of the construction project. Added difficulty in this regard is provided by the uniqueness of each project, as although they are unique they do not necessarily represent an innovation either during production or in its end state.

It is suggested that using the term process innovation in the traditional sense within the context of the construction project environment is not reflective of the context. Within manufacturing the term process innovation refers strongly to an innovation in the mode of production. Sexton and Barrett (2003) argue that construction is an industry that is driven by single and unique projects. The uniqueness of each project requires that the methods deployed are contextual to the requirements of the client's demands. The construction project requires a more sophisticated understanding of the contrasting form that the attribute of type exists within this context.

Three innovation types were identified to exist within the construction project environment; system, process, and component. To overcome the problems identified with using the term product and process innovation within this context, it was decided that differentiating the type of innovation through the relationship that exists between the innovation and the project was more representative. The following section will outline the form of each of these types. By distinguishing between innovations by type through the relationship between the innovation and the project it was intended that a more reflective and significant division of type was identified for analysis.

a) System

- System innovation- *refers to an innovation incorporating a new means of working through a new management structure or method/ relationship governing the project.* (Adapted from concepts by Rogers (1983) and Freeman (1989))

A system innovation by definition is an innovation that is governed and implemented from a higher level and then introduced within a project or across a number of projects. Systems innovations are of particular relevance in a management form, as the Rethinking Agenda (Egan, 1998) has suggested that the industry should assess the suitability of a number of manufacturing based management concepts and attempt to adapt them to their context. The industry has also been required to consider system innovations of a management nature aimed at improving the industry's methods of procurement and supply chain management in order to change the culture and efficiency of the industries project mode of production. Partnering is a good example of this trend and emphasises the definition of a system innovation that dominates or governs the project. System innovations are becoming increasingly significant as the industry attempts to improve the structural and cultural attributes of its mode of production. A system innovation could also be represented by a specific design laid down by the organisation for implementation within a number of projects. A good example of this would be in speculative house building where the house may be viewed as a product in the traditional manufacturing sense that is reproduced in a number of projects.

b) Process

- Process innovation- *an innovation where the project represents an innovation whether through its function or through the technological methods of its application.* (Adopted from concepts by Rogers (1983) and Freeman (1989))

An example of the process innovation can be illustrated within the industry by the present changes being made to environmental regulations, such as the sewage treatment side of engineering where currently there is a requirement for the introduction of innovative technologies in order to meet the new regulatory standards under the EC directive 76/160/EEC (SEPA, 2001). As a result, there are projects within this area that involve the design and construction of new sewage treatment processes, where the entire project's function represents the innovation. Wind farm projects and new developments into wave technology are other examples of process innovations and emphasis the point that the end- product of the project is the innovation.

c) Component

- Component innovation- *an innovation that refers to the creation and/ or implementation of a new element within the construction project.* (Adapted from concepts by Rogers (1983), Tidd et al (1997) and Freeman (1989))

Component innovations do not govern the project in the manner of the system innovation, and nor do they represent the function of the project in the manner the process innovation does. The component represents innovations that contribute to the project to allow for its completion. Such innovations can by their nature be managerial (i.e. new health and safety guidelines), technological (i.e. use of a new process for concrete mixing) or the introduction of a new product (i.e. a new window product). The component innovation contributes to the project by being one of many elements within its makeup. It is necessary to specify that those component innovations emerging as products from the construction-manufacturing sector represent a significant proportion of innovation activity within construction (Langford et al, 2001). These innovations many would argue are product innovations; however, within the construction project context it is necessary to state that although these innovations represent a product innovation for the organisations producing them, to the construction project they are merely a component of the wider project.

The three definitions differ because of the nature of interaction with the construction project. The system innovation exists at a higher level than the project, and governs the project. The process innovation exists as the function and purpose of the project, where as the component innovation exists only as an element of the project. The innovation within each of the types can exist as a management, technology, material or process method within each of these contexts. This understanding is in line with Tidd et al's (2003) definition for innovation.

It is anticipated that by distinguishing each of the types in this manner that the impact of the relationship between the innovation and the project will be captured for assessment. There is no research available considering these issues within this context. However, it is a logical line for assessment and one that overcomes the problems of using the product/ process approach. The research aims to assess the differences of each type and consider their implications on the innovation process and its management requirements.

Assessment of the attribute- to examine how different innovation types affect the management of the innovation process

Forms of the attribute- System, Process, Component

2) Scale of innovation

The definition of innovation provided by Slaughter (1998) states that an innovation requires to be nontrivial by its nature. However, when investigating the complexities of innovation and understanding the scale of the innovation, the term nontrivial is confusing, and the scale of the innovation could better determine the management requirements for its effective implementation. Tidd et al (1998) identified that in order to understand the scale of the innovation there is a need to consider the perception of the individual or organisation involved. The scale of the innovation is something that is relative to those involved (Burns and Stalker, 1994). Within the context of the construction project, the outlook of the project team towards innovation and change in general will influence the perception of the scale of an innovation. For example, it would seem logical to assume that a team that embraces change and innovations readily will perceive an innovation differently in terms of its scale than one that is reluctant. The mindset of a team towards an innovation and their willingness to engage and facilitate has implications for its management. As a result, there is a need to understand the scale of an innovation through the perception of the team towards it, in order to assess the implications for its management within a project.

The perception of the team towards the scale of the innovation is contributed significantly by the level of experience that they enjoy towards the actual innovation concept and of managing of the innovation processes. The level of previous exposure that a team have to an innovation (i.e. its degree of departure from established practice and familiarity with the concept) will affect their perception of its scale and potentially render the same innovation as displaying different scales within different projects. There is a requirement to study the potential management implications of these differences.

The definition of innovation states that those implementing the innovation should not have previous experience and only limited knowledge of the innovation. It is clear that whilst some management teams may not have experience or knowledge of the innovation itself, they may have an advantageous level of experience in handling and managing the innovation process than others. Kanter (1994) argued that organisations that can master change and innovation would be successful in business. It appears that the same logic can be extended to the project environment within construction. Project teams that can master the innovation process effectively will experience similar success, and enjoy a higher level of innovation process success. It would appear logical to suggest that a team that have experience and expertise at managing innovative ideas in general will have a better chance of success regarding innovation than a team who don't. Experienced teams can absorb radical innovations with complex linkages to the rest of the project far easier than those with little experience. This is an area that has not been acknowledged within the study of innovation, particularly within this context.

Tidd et al (1998) adopted the terms incremental, radical and transformational to describe the scale of an innovation, with incremental referring to minor improvements made for example to existing products, processes or systems. Radical innovations refer to changes to the 'way we think about and use them' (Tidd et al (1998)), and transformational covering innovations that are so radical and far- reaching that they change the basis of society. The terms radical and incremental are established within a wide variety of innovation literature for example Burns and Stalker (1994), Van de Ven et al (2000), Gann and Salter (2000) and Slaughter (1998). The literature review in addition to considering the lack of radical innovation within construction (Beck, 2001), cited Slaughter (1998) and her modelling of innovation by scale within construction, i.e. incremental, modular, architectural, system and radical innovations. Although over-structured, the value of her contribution regarding the need to consider the variations and complexities of innovation within construction is acknowledged.

Slaughter's (1998) observation regarding the effect that an innovation can have on the linkages and other components of the context of the implementation adds another dimension to the consideration of the scale of the innovation. It is clear that not only will the direct scale of an innovation (the extent of the change of practice) have an effect on its management needs, but that the difficulty of integrating innovation (complexity) with the project process will also require consideration. It is possible hypothetically that an incremental innovation can present a greater management challenge than a radical innovation if its ability to link to the project process is of greater complexity. Construction has failed to assess this issue within the context of innovation management, and this research provides an opportunity to observe if this logic is evident in practice.

The research will initially adopt two different scales for innovation, i.e. incremental and radical. This division will be based on the perception of individuals within project teams and represent the scale of the innovation. However, the suggestions within the literature of the need to characterise the complex nature of the linkages between the innovation and the project processes within this scale is worthy of investigation within the research. Potentially it maybe possible to produce firstly an attribute that is representative of the scale the innovation represents to the team, and secondly an attribute that represents the scale of the linkages between the innovation and project processes and the difficulty that this can present to its management. The research aims to explore the scale of the innovation further as an attribute and examine its influence on projects and the implications on management.

Assessment of the attribute- to assess whether the scale of the innovation affects the management of the innovation process

Form of the attribute- Incremental, Radical

3) **Source of innovation**

The source or context of the origin of the innovation has been identified within general management research by the likes of Tidd et al (2003), Burns and Stalker (1995) and Totterdell et al (2002) to represent a significant factor in the management of the innovation process. The origin of an innovation plays a significant role in the innovation process with examples relating to; resistance levels within the team (acceptance levels, trust, ownership, motivation etc), leadership, idea inception processes, development pathways, facilitation methods during implementation, and dissemination considerations. Totterdell et al (2002) emphasise the need to understand the source of the innovation in order to tailor the management of the innovation process to the particular needs and implications of that context of origin.

Despite this identification, research focusing on the source of the innovation as an attribute, has predominantly confined itself to those generated internally within the innovation process. This focus represents the by- product of the empirical reliance of such research on the manufacturing sector resulting in an understanding of innovation that is rooted in the product development model. For a sector such as manufacturing which is producer led, innovation that is generated internally represents an appropriate context for analysis. The processes of creativity and the resultant requirements of the management of the innovation process are therefore understood within this context. This reliance of the manufacturing sector on the internal generation of innovation is highlighted by the abundance of research conducted into the function of research & development within organisations, and the need to facilitate its contribution. Poole and

Van de Ven (2000) highlight the need for a psychology of creativity within an organisation and for management to support continually the environment to enable internally generated innovations to emerge. They also emphasised the value of developing a team's feelings of empowerment and ownership towards the concept. The volume of research assigned to understanding and facilitating innovation generation within this context exists in stark contrast to the apparent neglect of research into the importing of innovations generated from an external source.

There is a need within project-based industries such as construction to conduct research into the source of the innovation and to understand its implications for the management of the innovation process. The likes of Slaughter (1998) have conducted research into the influence of the source of an innovation within the context of the construction organisation, and Pries and Janszen (1998) have assessed the overall picture within the industry. However, there is a need to develop an understanding of the form and management implications of this attribute within the project environment, due to its predominantly temporal and client led nature. These two issues indicate that the construction project potentially receives innovation within its environment differently than within the manufacturing process, and therefore requires a level of understanding and management requirements that is rooted within this context.

The research aims to distinguish the source of an innovation as existing either as an internally generated innovation or as an imported innovation. Internally generated innovations are discussed at length within the context of manufacturing, but require to be understood within the construction project environment. By contrast, innovations that are generated and imported from external sources are a neglected component of research both within general management and within the project environment of construction. This failure to assess imported innovation concepts within manufacturing represents its lower level of significance by comparison to that of internally generated innovations. However, within the construction industry, imported innovations generated from external sources represent 81% of innovations (Pries and Janszen, 1995). Since the figure of 81% includes all aspects of the construction industry (organisations, projects etc), it would be logical to assume that within the project environment this figure would be slightly higher. Pries and Janszen (1995) identify within the construction industry that only 19% of innovation is generated internally, that specialist and suppliers (construction manufacturing sector) represent 27%, the academic community 35% and regulatory changes stimulate 10% of innovation. The construction project environment due to its temporal and client led nature clearly places less emphasis on internally generated innovation.

Construction's reliance on innovations that are imported from external sources potentially emerges from the perception within the industry that they represent a lower risk in their use. Management have potentially the opportunity to assess other examples of the innovation's previous implementation in practice, allowing for assessments to be made regarding its suitability and management requirements. Pries and Janszen (1995) address this issue and call for construction to break away from this perception in order for the industry to benefit from the potential that exits for innovation generation from within.

Research focusing on the internally generated innovation as a source within the manufacturing sector, focused predominantly on the implications for management of, facilitating the environment to enable the innovations generation and on the needs of managing the innovation process. Totterdell et al's (2002) observation that the source of the innovation has an influence on the nature of the innovation process and its management requirements, presents the question for this research as to whether internally generated innovations have differing implications on both the process and its management as those that are imported from external sources. General management research tends to focus on innovations that are internally generated and discuss the importance of achieving acceptance within a team throughout the innovation process for the concept. The likes of Poole and Van de Ven (2000) argue that management within such situations requires to deploy a range of strategies in order to facilitate these needs with the most common being measures to achieve ownership and empowerment within the team.

Research conducted into the source of an innovation within the project environment of construction has argued that innovation emerges in a far more informal (Slaughter, 2001) and bottom- up (Gann and Salter, 2000) manner than other industrial processes such as manufacturing. Much of the general management understanding of innovation describes the management needs of a process that is highly formalised and top- down by nature. Slaughter (2001) and Gann and Salter (2000) have been vocal in the need to empower those involved in the informal generation of innovation within the project environment as an effective tool for improving the current poor levels of innovation. Winch (1998) suggested that innovations emanating from the top of the hierarchy would require different management considerations than those beginning their journey nearer the bottom of the hierarchy. Winch argued that within the project environment there were barriers to the type of formalised top- down approach to innovation generation experienced within other sectors such as manufacturing. He identified a lack of incentive, the split roles of systems integrators and a relative lack of demand from the clients as factors that discouraged the utilisation and implementation of innovations generated within the project. Slaughter (1998) argues that in order to counter these barriers that construction requires to tap into the potential offered within the lower levels of the hierarchy (i.e. those on site), and to remove of the barriers that often restrict the desire for and actual implementation of bottom- up innovations.

There exists no research into this area with relation to internally generated innovations within the construction project and this is required, in addition to evaluating whether there is a difference in the manner that externally generated innovations require to be managed within this environment.

The failure of general management to consider that the source of the innovation may have an impact on the innovation process and its management requirements is rooted in the understanding it requires to include the invention component (i.e. as with product development models of the innovation process). However, within the construction project environment this is not the case with the dominance of externally imported innovations. There is a need to consider this as an attribute within the research and to identify if there is a difference between the internally generated innovations and those that are imported externally on the innovation process and its management requirements.

Assessment of attribute- to examine the impact that the source of the innovation has on the management of the innovation process

Form of attribute- Internally generated, Imported innovation from external sources

3.2.3 Outlining the project variables

There is very little appreciation within the literature of the potential influence that the different form of attributes of the construction project can have on the innovation process. There is a need to expose the realities and influence that different project attributes can have on the management of the innovation process. This review identifies two attributes that can be identified potentially as affecting the innovation process and its relevant management requirements within the project environment as the management style (whether the project is a temporary multi- party project, or is an in-house organisational project), and the funding regime (public or private).

1) Management style

The review has identified innovation within the organisational context of the industry and this perspective highlighted the importance of the structure and culture of the environment to which the innovation process exists. However, although there are many similarities it is possible to conclude that the organisation represents a different environment for innovation, to the unique temporal multi- party nature of the construction project. Gann and Salter (2000) have discussed the need to assess the existence of the innovation process within the project- based environment, due to the predominant focus within both construction and wider research on the needs of the organisation. Within construction, there exists a mixture of projects that either are by nature multi- party, or managed in- house within the confines of an organisation. Large contractor firms within the U.K. are increasingly fulfilling all the roles of the project team in- house in an attempt to get away from the confrontational atmosphere of the multi- party project. It is also clear that within this environment the in- house project can enjoy a greater degree of control of the project tailored towards their needs. It is necessary to assess the implications of this environment, in comparison to the multi-party temporary project environment, to assess the differences in the innovation process. The organisational environment potentially supports and facilitates the innovation process both culturally and structurally. Manufacturing organisations place considerable emphasis on this kind of supporting environment due to their regard for innovation as displaying long-term benefits that are quantifiable and retainable.

Yean Yng Ling (2003) cited Dulaimi et al (2002) who argued that within multi- party projects two groups of organisations emerge, those where the innovation originates and those that support it. She noted that the behaviour and nature of their interaction with the innovation differed depending on which group they belonged. The research will assess this assertion and compare its implications with that of the in- house project.

This research aims to assess whether in- house construction projects provide a similar level of structural and cultural facilitation for managing innovation. The research will contrast this with the multi- party project, which due to its temporary nature of its existence potentially may not be able to display similar levels of facilitation.

Assessment of the attribute- to assess the impact of the project's management style on the management of the innovation process

Form of attribute- In- house project, Multi- party project

2) Funding regime

The second attribute that has the potential to affect the innovation process and its management requirements is the political environment. This within construction projects largely relates to the form of the funding regime behind the project. The two forms of funding regime identified are those within the public or private sectors.

The Scottish Parliament building provides a useful example for explaining why public sector projects are perceived to experience a lower level of innovation culture than those within the private sector. This project was unusual within the public sector as the management team and the client were prepared to absorb the political fallout and financial burden of failure with the management of its innovations. The Scottish media has drawn considerable attention to the potentially wasteful nature of the projects use of innovation arguing that they are extravagant and potentially wasteful by their nature (Czarnocki and Murray, 2004). This project highlights many of the fears within public sector management teams of taking risks with innovations on limited budgets, as the levels of public scrutiny and potential political fallout of failure can be very damaging to those involved. Many within the public sector are reluctant to pursue innovative agenda's as a direct consequence of this, unless the budget agreed or political will is sufficient to absorb such a risk.

The traditionally held view (Czarnocki and Murray, 2004) of privately funded projects is that they embrace innovation largely due to their ability to absorb the financial risk associated with the innovation. Publicly funded projects tend to be guided by strict budgets that do not lend themselves to the risks necessary for an innovation culture.

There is no research evidence that backs these claims and it is necessary to assess which of these myths is true within the construction project environment. However, the form of this attribute has the potential to affect the attitude and cultural environment of the project towards the consideration of innovation.

The potential existing for the differing form of this attribute to affect the innovation process within the project environment of construction is considerable if unknown presently. The public and the private sector will be investigated in an attempt to understand not only the manner that innovation exists within construction, but also the manner of the construction environment in relation to innovation.

Assessment of attribute- to examine the impact that the funding regime has on the management of the innovation process

Form of the attribute- Private, Public

- **Summary of attributes**

Figure 3.1 displays both the set of innovation and project attributes and outlines the forms that will be assessed within the research. This aims to provide the research a basis from which to develop an understanding of innovation that is reflective of the construction project environment.

This set of attributes provides a means of being able to account for the unique nature of innovating within the project environment and provides the foundations for the development of a potential innovation process model. The development of the set of attributes allows individual case studies to be considered within its own particular context and allows for a level of cross comparison. Each attribute provides a line of enquiry within the research for the assessment of the implications of changes. The research intends to understand the implications of the differing form of the attributes on the innovation process and its management requirements.

Innovation attributes	**Form**
Type	System/ Process/ Component
Scale	Incremental/ Radical
Source	Internally generated/ Imported from external sources
Project attributes	**Form**
Management style	In- house/ Multi- party
Funding regime	Private/ Public

Figure 3.1: Set of innovation and project attributes

The next chapter of this thesis will identify the use of these attributes as forming the criteria of case study selection within the research. The use of the attributes should allow a spread of case studies that allow comparison of the form of each of the attributes. The research will also consider the prospect of developing attributes that reflect the complexity of the innovation in terms of scale but also its linkages with the project, and the capability of the management team. Chapter 9 of the thesis will evaluate the influence of each of these attributes on the management of the innovation process, in order to gain an understanding of the innovation process.

3.3 Main aim and objectives

The principle aim of this research is to understand the nature and management requirements of innovation within the construction project environment.

The objectives required to achieve this overall aim

- **Identify the nature of innovation and the impact of project attributes**

The literature review outlined the need for the development of an understanding of the innovation process and its management requirements that is reflective of the realities of the construction project environment. Koskela and Vrijhoef (2001) argued that construction would never achieve effective management of the innovation process until it understood the nature and requirements of the environment within which it exists. Gann and Salter (2000) called for research attention to be directed towards the project environment of construction and for innovation and its management to be investigated within this perspective. Totterdell et al (2000) identified that innovation is characterised by a number of attributes, and highlighted that the form of these attributes impact directly on the innovation process and its management requirements. In order to achieve the principle aim of the research there is a need to establish a set of attributes for innovation that effectively characterises its nature. This approach is common within general management research, although this has remained confined largely to models of product development based within the context of manufacturing. The form of each of these attributes will be outlined within the research with the aim of explaining how the innovations can exist with multiple characteristics, each potentially requiring consideration with relation to their management requirements. Koskela and Vrijhoef's (2001) issued concern over the lack of understanding within construction of the implications of the nature of the project environment on the innovation process. This research will aim to develop and explain a set of project attributes that allow an understanding of the potential implications on the management of the innovation process of differing project characteristics. This chapter has identified a set of attributes for the nature of innovation and the impact of project attributes. The research aims to evaluate the implications of these attributes on the innovation process and its management.

- **Develop a model of the innovation process**

The development of a model for the innovation process is acknowledged within general management research by the likes of Poole and Van de Ven (2000), as being the most effective method of achieving representation and developing an understanding of the process and its requirements. The literature review identified that established innovation process modelling is based empirically on the context of the product development process, primarily within the manufacturing sector. Baskerville and Pries-Heje (2001) argued that models require to be viewed as merely representations of their empirical observations, and that their findings and principles required to be observed within this context. The implications of this observation is that there is a requirement to develop a model for the innovation process within the construction project environment that is founded empirically purely on the realities of this context. Due to the neglect of research into this area (Gann and Salter, 2000), and due to the differing nature of this environment to that of the manufacturing sector, (i.e. construction projects being client led and predominantly temporary by nature, and manufacturing being producer led and organisational by nature), there is a distinct need for such a model to be established. Only by developing a model that is grounded in the complexities and realities of the construction project environment, can comparison be effectively drawn with the established models of general management. A model that is reflective of the task of managing innovation within this context would make a significant contribution to improving both the understanding and management of the innovation process. The research will require a methodology that is reflective of these empirical needs and will use the innovation and project attributes identified within this chapter as the criteria around which to base the case study selection process. The nature of the empirical sample will reflect the overall quality and scope of the model.

- **Assess the impact on the model of different types of innovation**

The three types of innovation outlined in this chapter (i.e. system, process and component), were reflective of the differing relationships observed between the integration of the innovation process and the project process. The observation that the innovation process exists in three forms representing different relationships of management governance between the innovation and the project, requires further consideration. The research aims to investigate the structural implications of these distinctions on the research model, and on the nature of the management requirements. There is a need for management to understand the implications of these differences in order to achieve the successful integration of the two processes.

- **Identify the management success factors for the innovation process**

The literature review identified the development of management success factors as a common output from research conducted into the management of the innovation process. Success factors provide an understandable link for the practitioners between the generated theory and model, and the requirements and needs for successful management of the process. This research aims to identify a set of management success factors that reflects the practical requirements of managing the innovation process within the complex environment that is presented by the construction project. There exists a neglect of research and understanding of the implications of managing an innovation process within this context, and the need exists to resist the temptation for adopting factors identified from out with this empirical context. Using the model and the success factors, practitioners can develop a better understanding of the nature and requirements of the innovation process and therefore improve their interaction with the process.

- **Identify the relationship between the management success factors and the innovation and project attributes**

The research aims to provide an assessment of each of the attributes and their impact on the performance of the management, and suggest additional facilitation measures should they be deemed necessary. Such an understanding will aid the practical delivery of a tailored management response suitable for the requirements of the context. The research aims to develop a management tool for use by practitioners reflecting the requirements for successfully facilitating the management of the innovation process.

The following two chapters outline the methodologies selected in order to satisfy these research objectives. The need to ground the research findings within the practical realities of the construction project environment will be highlighted through the selection of those methodologies. Chapter 4 provides an evaluation of the theoretical justification for the methods selected and chapter 5 discusses in detail the practical realities of implementation.

Chapter 4

4 Methodology

4.1 Introduction

The methodologies chosen and implemented within any research project are of particular importance in guiding the direction and determining the quality of the research conducted. Within this context, they are essential for ensuring the validity and representative nature of the situation under investigation due to the complex nature of the environment in question. The literature review outlined the need for an understanding that was reflective of the realities of both the theoretical and practical implications of managing innovation in construction. The methodology discussion within this thesis is divided into two chapters. This chapter will examine the theoretical framework and conceptual basis behind the selected methodology, revealing the adoption of a qualitative approach using grounded theory to analyse empirically based case studies. The following chapter intends to examine the practical observations of its implementation.

4.2 Ethos of the research philosophy

As outlined previously the research aims to develop an understanding of the nature of the innovation process and its management requirements within the 'complex and multi faceted' environment that is the construction project (Slaughter, 1993). In order to achieve this objective a method of measuring and understanding the interaction between the innovation process and the project environment must be developed. The previous chapter identified a set of attributes for both the innovation and project from which such an understanding can begin to develop, however this only provides the framework. The methodologies selected have to produce an accurate representation of the theoretical existence of the innovation process, and to establish the management requirements for ensuring its success. In order to achieve this, two key considerations demand observation within the selected methodology the difficulties of modelling such a complex series of interactions, and the need for an approach that would ensure the representative nature of its findings.

4.2.1 Difficulties of modelling complexity

The previous two chapters have outlined the complex nature of both the innovation concept (multi faceted in its nature) and the project environment (unique and temporal). The research objective of assessing the nature and practical management requirements of their interaction, presents a complex and challenging empirical context for assessment. The challenge of understanding and modelling this level of complexity presents many difficulties from a research perspective and the aim of producing a representative model. Within this, there remains a need for any model and understanding developed to be an accurate abstraction of reality. Consequently, a research methodology is required that allows the complexity to be understood, whilst binding the research findings to the realities of the situation without its misrepresentation or the infringement of wider influences. To ensure this, a methodology requires to be selected that observes the strict principles of social research laid out by the likes of Sarantokos (1998) and Glaser and Strauss (1967). There follows a discussion of the difficulties of modelling complexity, prior to outlining within the next section the principles of the post modernist philosophy, a philosophy selected within this research in order to provide a framework for interacting accurately with complexity (Massey, 1994).

The intention to develop a model reflective of the understanding of the innovation process is a common approach taken when assessing innovation within management research. Indeed, modelling within research generally has increased in popularity as a method of easing the understanding and representation of complex phenomena occurring within the environment to which we live. Wallace (1994) defines the use of a model within research as being the 'process of developing and providing an abstraction of reality.' Increasingly however, the use of models as a research tool is being questioned within academia for their ability to accurately represent a situation (point cited in Gummensson (2000)). Wallace (1994) warns of the potential harm that can be caused when a model builder or user fails to recognise the value and assumptions on which a model is founded. Wallace focuses on the role of modelling within mathematics; however, sociologists and management researchers (Gummensson (2000) and Huber and Van de Ven (1995)) are recognising that many of the problems relating to the achievement of a valid representation are similar. The increased popularity of modelling the findings of social or management research has clearly resulted in abuses of ethics both knowingly and unknowingly within research (Gummensson (2000), Glaser and Strauss (1967), Huber and Van de Ven (1995)). Academics such as Strauss and Corbin (1990) raised concerns over such abuses, citing the lack of awareness of many researchers relating to their position when producing such models. This criticism refers to the imposition of outside influences on complex situations by many researchers, a problem discussed in length in the literature review with relation to modelling.

To acknowledge these issues within this research it is proposed to adopt a methodology reflective of the reality of the situation. The ability within a research project to accurately understand and produce a model is a difficult task, requiring the entire ethos of the methodology to be focused on its production thus ensuring its methods represent the reality. This is perhaps a logical statement; however, within research (particularly qualitative) commonly mistakes and misrepresentations are made solely through the adoption of the wrong techniques for analysis, and the researcher spoiling the sample. The following section outlines the post modernist philosophy to research, a philosophy that provides the framework for potentially overcoming the problem of misrepresenting complex phenomena.

4.2.2 Post modernist philosophy

The post modernist philosophy to research has emerged in the last two decades in response to concerns relating to the misinterpretation of complex phenomena through the use of a modernist approach to research. Post modernist researchers such as Massey (1994), Massey et al (1999) and Laurie et al (1999) argued that using the modernist approach, resulted in assessing situations by imposing a structural approach to analysis and interpretation, and thus preventing the fluidity and the emergence of the context within research. The use of predefined categories for sorting information is a good example of modernism within research, and it can emerge in both quantitative and qualitative approaches. The modernist framework is useful for research that assesses environments with predefined boundaries and an established high level of understanding (Taylor, 1999). However, the dangers of using such an approach within environments of little understanding, where the boundaries are not well defined, runs the considerable risk of imposing ideas from out with and misrepresenting the reality of the situation. Research projects such as this one require to avoid an approach that relies on generalisation, due to the lack of understanding into the nature of the innovation process within the construction project environment.

The post modernist approach by contrast aims to avoid the dangers of stereo- typing and the categorisation of complex issues and situations (Laurie et al, 1999). Whereas the modernist approach imposes structure, the post modernist approach aims to allow structure to emerge from the environmental context. Post modernist researchers such as Massey (1994) and Laurie et al (1999) argue that the modernist approach is too rigid and neglects the potential for the fluidity of meaning and understanding to emerge within complex environments. The value of such an approach was first observed within sociology where researchers of culture began to recognise that individuals within society existed with multiple identities and that it was misrepresentative to identify them as solely belonging to one identity category (Massey et al, 1999). This approach aims to avoid the misinterpretation and categorisation of stereotypes, thus allowing the subject under consideration to be assessed from the perspective to which it actually occurs and enables conclusions to be drawn by avoiding generalising the situation (Laurie et al, 1999). Whilst the foundations of this approach emerge from sociology (May, 1997), the likes of Gummensson (2000) argue that the nature of the industrial environment and its management benefit just as much from the use of this approach. There are many criticisms of the post modernist approach, and it is often accused of being directionless and lacking focus due to the absence of structure (Massey et al, 1999). However, within the context of this research such an approach is appropriate due to the undefined nature of the innovation process, the approach would therefore allow theory to emerge from the empirical examples provided as opposed to forcing the theory by applying preconceived structure.

The post modernist philosophy also differs from modernism in relation to the perception of its findings and their value. Post modernists criticise the modernists for their acceptance of findings as being definitive and applicable for generic application (Massey et al, 1999). Gummensson (2000) argues that such an approach is dangerous as the conclusions and findings of research are merely representations of a particular situation, and other case- studies or surveys may reveal different observations. The post modernist approach acknowledges the contextual nature of the empirical sample and argues that this must be recognised within any model produced. Indeed many such as Massey (1994) argue that the emergence of a model across several case studies is unrepresentative, as it ignores the contextual nature of each. Whilst the research acknowledges this point, a need exists to at least attempt to assess the potential for developing a generic model. Only by conducting such an assessment will it be possible to understand the nature of the innovation process, and identify an approach to improve its management. It is necessary to root observations made across different case studies to the nature of their individual context, in order to be respectful of the unpredictable and dynamic nature of each. Only when the empirical examples (or case studies) are regarded as representative of the environment in question through theoretical saturation can generic models be produced and regarded as such. Glaser and Strauss (1967) argue that theoretical saturation is the point when no more case studies or examples will alter the nature of the findings. Without due consideration of rooting the findings in the contextual nature of each case study, such an approach would be unrepresentative, as it would be open to criticism for overly generalising complexity. Such considerations form the ethos of the methodologies within this research, and will be developed and described over the remainder of the chapter.

4.3 Selection of the qualitative approach of methodology

The adoption of a research philosophy provides the framework within which the research methodologies are guided. Following the decision to adopt a post modernist philosophy, there is a requirement to identify the nature of the methods and the techniques deployed in order to satisfy the research aim and objectives. This section will identify the use of a qualitative approach of methodology and provide justification of its selection. When considering the complex nature of the interaction between the innovation and the project environment, the adoption of such an approach is logical.

The use of qualitative methods of analysis within management research has only re-emerged in the past ten to fifteen years (Gummensson, 2000) as a valid and effective methodology for use. The use of qualitative methods is widely acknowledged as the tools or techniques used when modelling complex situations to overcome the difficulties during assessment. Much of the theoretical discussion has been based on assumptions and concepts from social science disciplines where qualitative methods are valued and heavily implemented as an approach for research. Van Maanen (cited by Gummensson (2000)) argues that the qualitative form of analysis within academic management research has in the past been regarded as the poor relation to the use of quantitative analysis (including the importance of statistical analysis) largely since the middle of the last century. However, he argues that the foundations of management theory were founded from the use of qualitative methods in the past, and as we enter the 21st century the importance and value of this form of analysis is beginning to be recognised within some quarters of management research. Pointing to the works of the great management pioneers such as Fredrick Taylor through to the Hawthorne studies, qualitative methods formed the backbone of which management theory has traditionally been constructed. However, for nearly half a century this type or form of analysis has been neglected by academia, as a tendency existed to focus on quantitative approaches (Gummensson, 2000).

Qualitative methods have been adopted and developed within the sociological disciplines during this period, and has successfully evolved as a discipline able to generally interact with and understand the behaviour of people within society. Management research is beginning to recognise that when attempting to explain the behaviour of humans, quantitative analysis, fails overall to understand why they behave the way they do (Gummensson, 2000). Useful for identifying patterns, quantitative analysis lacks the necessary explanation and appreciation to be able to get the root cause behind such behaviour. Qualitative analysis however allows the researcher to gain access to the mindset of an individual's perception of life and reasoning for their subsequent behaviour. Only by understanding the reasons why an individual or group behave in the manner they do is it possible to model their behaviour and interactions. This is an observation that was made within the Hawthorn studies that would have simply been impossible if the research had been conducted in a quantitative manner, as the level of understanding would not have been sufficient.

The quantitative approach assesses predominantly for patterns during analysis of largely numerical data, whether it be financial, frequency, or quantity related. The main tool for analysis within this approach is for statistical analysis of such data, and within the correct context, this is a powerful tool within research. However, within the context of this research, the type of 'data' requiring measurement centres on the structural and cultural interactions and behaviours of both individuals and groups with the innovation process and its management. The level of complexity of the interaction between the concept and the environment is not something that can be measured through numerative data, but rather has to be considered using a qualitative approach. The common tools of the qualitative approach are the interview and the questionnaire survey. Both these techniques attempt to engage with the process in question through the measurement of the opinions of those involved. The analysis involves the assessment of the 'data' for patterns and trends that occur, in an attempt to interpret the process in a manner that can lead to the development of an understanding. This form of analysis allows for the context of the situation to be retained during assessment, and the root cause identified and understood. This is a type of interaction not possible with a quantitative approach.

Qualitative analysis will form the basis for the methodologies within this research. Consequently, the qualitative methods selected must engage with the concept of innovation within the context of the project environment. Therefore, it is necessary to ensure that the tools and techniques selected reflect the post modernist philosophy previously presented. Such a method must provide the research with appropriate methods in order to ground the findings and conclusions in the context of the project environment. The following section will conduct a review of two important methods of qualitative methodology i.e. content analysis and grounded theory, prior to presenting the most suitable and its application to the research.

4.4 Review of qualitative methodologies

There are two qualitative techniques for contemplation when considering appropriate methods for analysis in relation to the aim and objectives of this research, qualitative content analysis and grounded theory. Both of these approaches satisfy the basic requirement of qualitative research through the understanding that they produce findings not arrived at by statistical procedures or other means of quantification. Straus and Corbin (1998) argue that many researchers fail to understand the principles behind qualitative analysis and obtain data through 'means of interviews, observations, and techniques' and then code the data in a manner that allows them to be statistically analysed. This process is regarded as 'quantifying qualitative data'.

These two methods are based very much on the principles of coding and analysing the qualitative data in a 'nonmathematical process of interpretation, carried out for the purpose of discovering concepts and relationships in raw data and then organising these into a theoretical explanatory scheme' (Straus and Corbin, 1998). Both qualitative content analysis (Mayring, 2004) and grounded theory (Strauss and Corbin, 1998) assign to the principles and ethics discussed previously by aiming to base their findings within the context of the given sample. May (1997) argues that for qualitative content analysis the findings of research are to be understood within the context of its production, and Straus and Corbin (1998) highlight that grounded theory was derived from the data (i.e. the context to which it was gathered). Whilst there are many similarities between the two techniques, there is a fundamental difference in their philosophical framework reflected in their approach to analysis, thus rendering one of greater suitability for this research than the other.

Content analysis employs a systematic approach as well as standards and principles found in all methods of social research (Sarantakos, 1998). Within qualitative content analysis, the technique is directed towards subjective information, such as motives, attitudes and values. The analysis of documents under content analysis, Sarantokos (1998), Mayring (2004) and Silverman (2001) argue is divided into two types of content or levels of analysis, either manifest content or latent content. The manifest content refers to 'the visible, surface text, the actual parts of the text as manifested in the document, i.e. words, sentences etc which form the visible content of the document and involves counting frequencies of appearance of the research unit' Sarantokos (1998). The other level of focus is on the latent content, which refers to the underlying meaning conveyed through the document. This refers to the 'researchers ability to read between the lines and exposes the hidden significance of the object of study. This level assesses the implied meanings behind the words and sentences used and provides indicators of the presence and frequency of the occurrence of 'meaning'' (Sarantokos, 1998). These understandings highlight that content analysis is predominantly dominated by a process of detection for concepts and categories generated prior to analysis, and a process of interpretation based on their presence or absence within the context.

Content analysis acts as a process of filtering out aspects of the material, to make a cross- section of the material under ordering or to assess the material according to particular criteria (Mayring, 2004). This observation allows for the rational behind content analysis of coding a document (predominantly an interview and open- ended questionnaire transcript), to be understood as a mode of assessing a number of predefined theories and concepts (categories). The process of coding the document allows the researcher to compile the frequency levels of both the manifest and latent content in line with the existing theory or categories. There is sufficient room within the process for the theory or categories to be adjusted in line with the observations from the findings. Content analysis essentially allows data to be analysed for the presence or existence of a theory or understanding that has been established prior to research beginning. There is a growing trend with the use of content analysis relating to the allowance for inductive category formation (development of categories gradually from some material) (Mayring, 2004), however this activity remains locked in the philosophy of theory testing and adapting as opposed to building.

The use of content analysis can allow for the acceptance/ rejection of theory, provide explanation for the theories existence and allow for the adjustment of the theory in line with the reality. This process follows the principles of the modernist philosophy outlined in 4.2.2, and as a result is only suitable for analysis within environments where the boundaries are predefined and previous knowledge exists. Under this rational the theory is tested against the established knowledge of the environment, or an established theory is tested against a new environment. Within this research, due to the undefined nature of the innovation's interaction with the project environment, to use the process of content analysis would run the dangers of misrepresentation when trying to generate a model. It can be used for testing the fit of established models or to prove or disprove whether the situation was aligned to any of these theories, but fails to allow for the valid generation of a model grounded in realties of the context. The absence of an established theory reflective of the context, would risk imposing theory or structure established from outside influences if content analysis was used.

Grounded theory is a technique created by Glaser and Strauss in the late 1960's. The co- authors of the book 'Discovery of Grounded Theory' (1967) defined grounded theory as a method of analysis that 'begins with the area of study and what is relevant to that area is allowed to emerge'. A grounded theory is one that is inductively derived from the study of the phenomenon it represents. Strauss and Corbin (1998) and Glaser and Strauss (1967) argue that grounded theory is an emergent theory and as a procedure cannot be learned in the form of prescriptions. They argue that grounded theory is derived from the data, systematically gathered and analysed through the research process. It is strongly argued that a researcher using this method does not begin research with a preconceived theory or concept, but begins with an area of study and allows the theory to emerge from the data. Content analysis on the other hand is a research process that is systematic in its approach from an initial preconceived standpoint theoretically that requires analysis within the given context.

Both theories use the process of codification and the use of categories to order thinking during analysis, however their interaction and use of these tools differ considerably due to their alignment to different philosophies of research. Assessment of the two approaches reveals that content analysis represents a tool of the modernist philosophy of research, whereas grounded theory emerges as a tool used by the post modernists. These two methods operate under very different theoretical frameworks, and realisation of this aids the decision over which to use within this research.

The identification that grounded theory emerged as a tool within the post modernist philosophy aligns it strongly with the requirements identified for modelling complexity within section 4.2. Although the stages of the research process are structurally similar between the two processes (Sarantakos, 1998), the function of the methods differ in application. Strauss and Corbin (1998) argue that the interplay between the researcher and the data differs (i.e. their positioning) when comparing grounded theory to content analysis. Grounded theory as discussed, aims to allow the theory to emerge from the data. Coding requires to emerge from the situation as opposed to being influenced by preconceived ideas or theories/ categories. Grounded theory relies on the process of coding patterns within the data, forming categories, identifying their relationships and trying to understand the overall meaning through the generation of theory. This contrasts heavily with content analysis and its focus on testing theory and assessing the frequency of the appearance of codes. The process of grounded theory will be outlined in detail within the following section; however, as a process it is necessary to identify its fluid and responsive nature during the emergence of a theory.

Grounded theory as a process significantly removes the influence of the researcher and their perceptions from the analysis, guarding against the dangers of bringing preconceived ideas and concepts in to the research gathering and analysis process. Strauss and Corbin (1998) highlighted principles to which the philosophy of grounded theory requires to be based, 1) ability to step back and critically analyse situations, 2) ability to recognise the tendency towards bias, 3) ability to think abstractly, 4) ability to be flexible and open to helpful criticism, 5) sensitivity to the works and actions of the respondents and 6) sense of absorption and devotion to the work process. These principles stem largely from the post modernist philosophy and reflect the objectives of theory generation as opposed to theory testing. These principles will be observed within the grounded theory process described in the next section.

The process of grounded theory has been criticised by some circles for its lack of focus and structure. Modernists feel the lack of a systematic and structured approach presents a directionless process lacking clear objectives. However, the likes of Strauss and Corbin (1998) argue that this only results in practice from inexperience of the process or misinterpretation of its objectives. The fluidity and responsive nature of the process are the two attributes of the method that provide its strength, however it is clear that many practitioners find this difficult to master in practice. The following sections will reveal grounded theory to be a difficult process for practitioners to effectively master, and one that is vulnerable to contamination and misrepresentation if its rules are not observed. However, a detailed understanding of the process and its objectives provides the potential of a scientific approach to understanding complexity.

4.5 A review of grounded theory

This section aims to outline the nature of grounded theory and discuss the concerns and implications of its practical implementation. This section is split into two sub sections, outlining of the grounded theory process and a review of software as a research aid during implementation.

4.5.1 Grounded theory process

This section addresses three issues that require careful consideration during the grounded theory process, issues of data collection, the nature of the grounded theory process, and its practical application.

a) Data collection

The quality of the data has a direct consequence on the research findings. The nature of the tool used for gathering the data therefore takes on significance, particularly for an approach such as grounded theory. Grounded theory is a method traditionally applied to transcripts obtained from interviews, open-ended questionnaires and archive documentation, where patterns within the data are identified and assessed for understanding. The need within the research for an approach that is reflective of the situation under consideration requires a tool that is responsive to the nature of the sample. When considering the use of interviews within this context, there is a need for respondents to provide the ideas and understandings of the situation. Interviews therefore require to be constructed in a semi- structured composition (Glaser and Strauss, 1967), but with enough room to allow for open- ended discussion when desired by the respondent. The openness and flexibility of the interview process is important to allow an understanding to be gained of the context to which it is set. The interviewer needs to retain neutrality and objectivity within the process, and to avoid the tendency of enforcing preconceived ideas on the process directly by influencing the respondent with leading questions. Keats (2000) warns of the dangers of harming the sample and the realisation that a harmed sample is worthless from a research validity point of view. During the process of data collection, there is a need to retain the philosophy of allowing the theory to emerge. Consequently, the interview requires to be well prepared, as failure to do so would run the risk of spoiling the quality of the data.

b) Grounded theory process

This approach requires a considerable proportion of fluidity and flexibility as a process in order to provide the reflective capabilities necessary for the engagement with the realities of the empirical context. In order to achieve this, the grounded theory process requires to allow the data to emerge and for the researcher to resist the temptation to push the outcomes of the process. Strauss and Corbin (1998) identify the interplay and relationship between the data and the researcher as being of crucial importance when performing the grounded theory process. In order to aid this interaction they highlighted five procedures that require to be observed during the process, 1) to build rather than test theory, 2) provides researchers with analytical tools for handling masses of raw data, 3) help analysts to consider alternative meanings of phenomena, 4) be systematic and creative simultaneously, and 5) identify, develop and realities the concepts that are the building blocks of theory. These procedures clearly differentiate the process of grounded theory from that of content analysis through the emphasis on allowing the theory to emerge from the data, the theories position within the context of generation, and by highlighting the need for its tools to be reflective and fluid in their interactions.

Hildenbrand (2004) cites Strauss's view that grounded theory was a process of investigation where theoretical concepts are developed in the data and have to prove themselves in the data, as there are no criteria. Strauss observed the process as being triadic and circular in its form (flowing as a triangle with data collection, coding and writing memos, as the points). Strauss and Corbin (1998) argue that it is important not to separate the phase of collecting material from that of analysing it, but 'to bond them together and to collect only as much material as is necessary for the analytical process.' Within any grounded theory process there is a need to understand that there is a continual need to revisit activities and assess the implications of the findings throughout the process until the principles of saturation are satisfied. Glaser and Strauss (1967) identified the saturation point, as the point when the researcher observes that revisiting activities will not change the nature of the findings of the process, and thus provide indication to the researcher that the process is complete. This is a basic requirement when theory and model building using an emergent approach, that is not required to the same extent when testing established thinking as within content analysis.

The emphasis placed on the need for fluidity and reflection within the nature of the process has resulted in various examples or interpretations of the different steps of the grounded theory process. Figure 4.1 illustrates two of these interpretations, 10 steps by Sarantokos (1998) and 8 steps by Hildenbrand (2004). Both these examples illustrate significant similarities and indeed essentially describe a process that shares the same founding principles and techniques for analysis. Both incorporate the five procedures highlighted by Strauss and Corbin (1998) illustrating the significance of the steps of theory identification and development, whilst retaining the need for reflection and fluidity through a process of constant feedback. They both illustrate the processes of coding, the building of categories, the development of theory, and the testing and refining of this theory to satisfy saturation principles.

The differences between the two examples largely reflects a different manner of describing the process, however it is clear that Hildenbrand's (2004) version is based on Strauss and Corbin's (1998) interpretation, whereas Sarantakos (1998) was citing the works of Glaser and Strauss (1967). Glaser and Strauss, although both the founding fathers of grounded theory, disagreed in later years regarding the extent to which the process should be prescribed for practical application, and the extent that this allowed

Sarantakos (1998) **10 steps following Glaser and Strauss's process**	**Hildenbrand (2004)** **8 steps following Strauss's process**
1. Identifying indicators in the research topic 2. Studying indicators and comparing them with each other 3. Coding indicators, looking for answers and formulating hypotheses 4. Categorising similar indicators as a class 5. Naming the class and perceived it as a coded category which reflects the indicator's similarities, and the smallest common denominator-conceptual code known as a concept 6. Comparing indicators with concepts and other indicators 7. Working through more attributes of the categories, refining them and getting additional information until the codes are tested and saturated, that is until no more new information is gained 8. Developing and saturating more categories through the process of constant comparisons 9. Developing and saturating the theory and concepts 10. Further testing, contrasting and comparing of theories and perhaps refining and changing them	1. The researcher asks questions of the material (coding) supported by the coding paradigm 2. During the coding process concepts are developed, setting of hypotheses to capture ideas, the process of establishing connections between these concepts, emphasising the importance of repeating coding to provide a denser concept- based relationship which in turn leads to theory 3. The constant checking of the emerging theory through the process of contrasting (theoretical sampling) with examples in order to check theories 4. New data are constantly coded 5. Integration of concepts lead to one or more key categories and thereby the core of the emerging theory 6. Theory memos are provided for the individual components of the developing theory and placed into a relationship 7. Final phase of theory development it may seem advisable to collect and code new data- continued proof theory 8. The framing of the emerging theory through the process of creativity during writing

Figure 4.1 Comparison of different interpretations of the grounded theory process

the theory to emerge as opposed to 'forcing' theoretical structures. Glaser (1992) criticised Strauss and Corbin (1990) for being too prescriptive in their interpretation of the process to the user, and argued that this threatened the ability of the researcher to allow the theory to emerge from the data sample using the principles of saturation.

Glaser's (1992) concern related to the manner to which Strauss and Corbin (1992) described the coding process, and argued that their interpretation was too prescriptive. Coding is recognised as the process where concepts are identified within the data, and connections are made between them. Hildenbrand (2004) referred to this as asking questions of the material, and the development of concepts from the coding, whereas Sarantakos (1998) refers to it as the identification of indicators within the data that are compared with each other, and then assigned codes based on hypothesis and answers. This is a constant process that emerges and is revisited throughout the grounded theory process. Glaser (1992) criticised Strauss and Corbin (1990) over what he felt was the over prescriptive nature of their coding of data, and particularly through their adoption of axial coding.

Strauss and Corbin (1998) highlight different techniques for coding such as open coding (the analytic process through which concepts are identified and their properties and dimensions are discovered in data), axial coding (the process of relating categories to their subcategories, termed 'axial' because coding occurs around the axis of a category, linking categories at the level of properties and dimensions), selective coding (the process of integrating and refining the theory) and coding for process (sequence of evolving action/ interaction, change in which can be traced to changes in structural conditions). Eaves (2001) displayed a diagrammatic representation of Strauss and

Corbin's coding techniques, which illustrated their relationship with the wider process. This representation is displayed in figure 4.2 and highlights the activities of the process that Eaves (2001) viewed as significant within the context of the types of coding. Glaser's (1992) criticism of the use of different types in this manner was that the process becomes prescriptive in a manner that moved a way from the initial concept of simply 'coding' the data in response to the data under the principles of saturation.

Charamaz (1990) argues that Glaser's (1992) concerns regarding the conceptual progression of grounded theory as a process are justified and fears that a move to understand and produce a prescribed process for grounded theory is resulting in research that has a tendency to stray from the needs of the methods of the philosophy. Glaser (1992) argues that Strauss and Corbin (1990) interpretation of the grounded theory process has sparked research that searches for a representation of the process for practical use. Chesler (1987) provided such a diagram highlighting the principle activities of the process from a practical perspective of the grounded theoretical approach. This can be observed in figure 4.3 and Eveas (2001) identifies Chesler's representation as being of particular relevance for the novice grounded theorist. She highlights the need for novice users of the theory to enjoy a practical understanding of the theory as well as a theoretical one, as it is claimed that theoretical mistakes emanate from practical confusion.

The goal of generating an understandable and practical representation of the grounded theory process stemmed largely from the high frequency of failed implementations of the approach in practice. Strauss and Corbin (1998) were concerned that this reflected

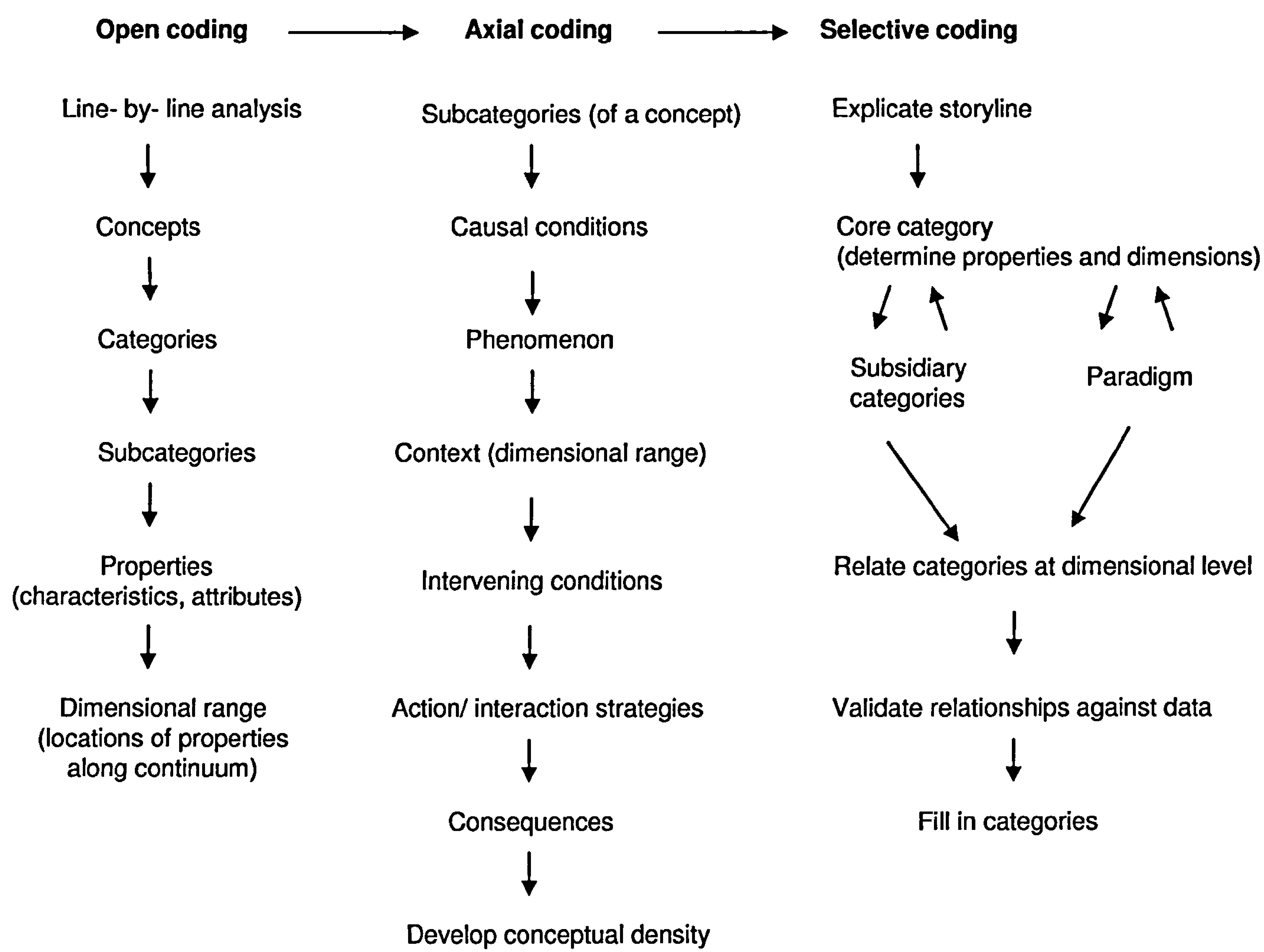


Figure 4.2 Diagrammatic representation of Strauss and Corbin's (1990) coding and analysis of grounded theory as cited in (Eaves, 2001)

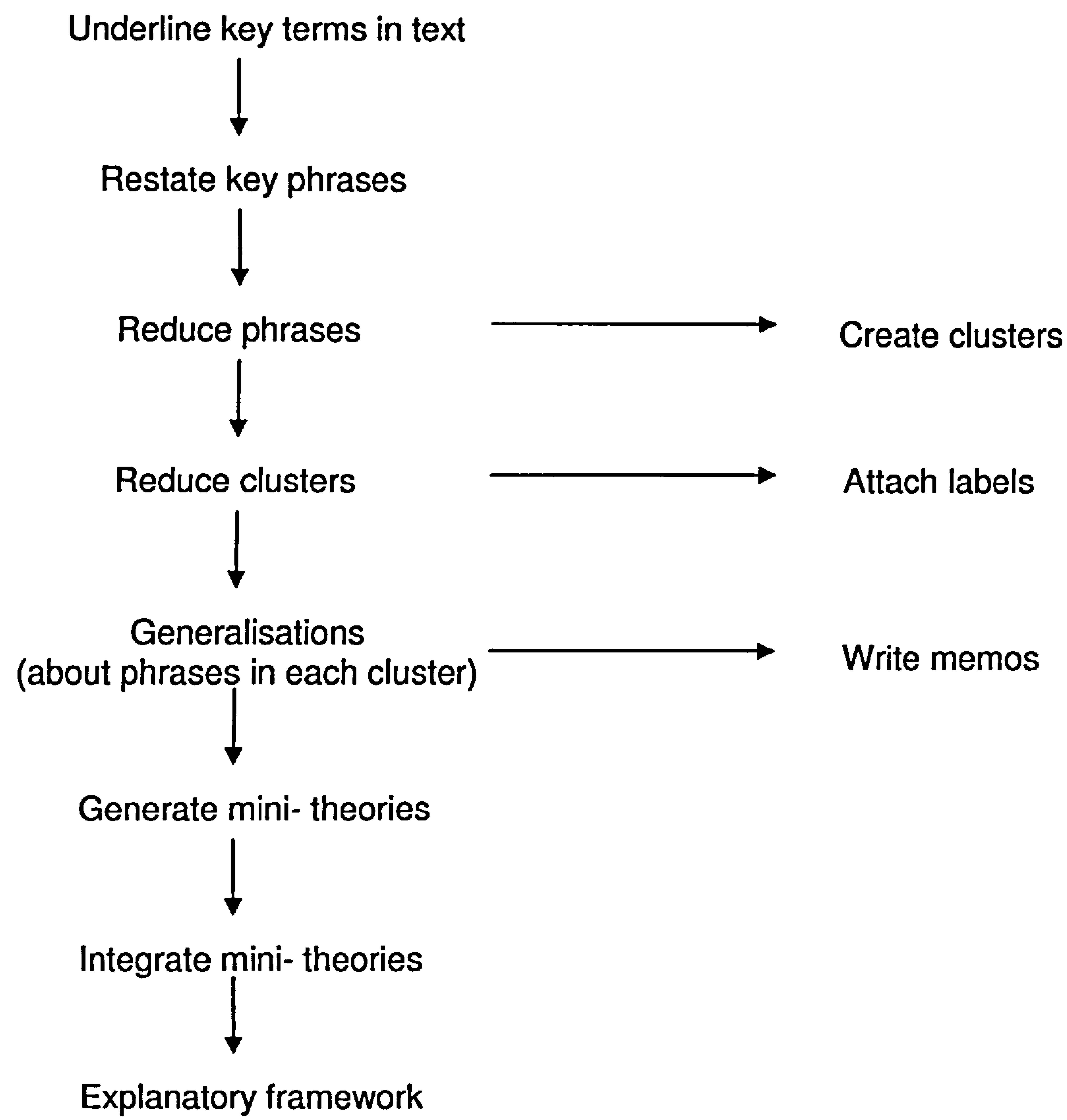


Figure 4.3 Chesler's (1987) Grounded theory approach

an inability to understand or a lack of experience of the practical implications of using the process. The fluid and emergent nature of Glaser and Strauss's (1967) approach presents difficulties for many practitioners due to its lack of procedure within the process. By providing a greater understanding of the practical requirements of using the process many, such as Eveas (2001), hoped that in addition to increasing the ease of use of the processes that the traditional problem associated with the adoption of the post modernist philosophy could be avoided. Many modernists accused grounded theory of failing to find a research or conceptual direction often as a process due to its reliance on allowing the theory to emerge from the data. Eveas (2001) argued that by enhancing the understanding of the practitioners of the process and its tools (i.e. coding) that the potential for this problem could be minimised.

Whilst practical confusion is a recognised problem within the use of the process, significant debate exists over the potential harm the search for an understandable practical process is doing to the foundations of the approach. Charamaz (1990) argues for example that there are many instances of grounded theory research that suffer from premature commitment to analytic categories, unnecessary jargon, and a lack of clarity about key terms (for example, theory, category, and saturation). Eveas (2001) draws attention to the observations of Thorne (1997) who argues that the use of abbreviated procedure processes for grounded theory is increasing a culture of 'sloppy' research. They warn that the use of abbreviated and procedural processes within the application of grounded theory has resulted in researchers failing to engage 'with the underlying assumptions of the qualitative method they have employed' (Eaves, 2001). Glaser (1992) was concerned that the search for a practical process was placing procedure on the process that damaged the foundations of the concept, by endangering the completeness of the judgement regarding saturation.

Within the discipline there exists debate regarding Glaser's (1990) concern over Strauss and Corbin's approach to the process. Eaves (2001) cited both Benoliel (1996) and Melia (1996) who disagreed that Strauss and Corbin (1998) had neglected the principles of grounded theory in practice, and view this as adding to the development of the theory's evolution. They concluded that it is the role of knowledge to re- examine methodologies and allow them to develop. Benoliel (1996) added that grounded theory research needed to increasingly observe the basic social processes of the context to which they exist, as there was considerable evidence that illustrated a general failure to appreciate this aspect of the process. He highlighted the need to conduct grounded theory research as opposed to adopting a grounded theory approach. Benoliel (1996) suggests that this is ensured by a constant comparative method, theoretical sampling, multiple comparison groups, and theoretical coding. Without the satisfaction of these principles the research process fails to satisfy its objectives and procedures, producing results that are not valid for the purpose they were intended. Within this understanding, the principles are reinforced throughout the process, whilst allowing a practical focus to emerge within the research using the tools and techniques developed within Strauss and Corbin's (1990) process.

It is clear from the research that although there have been attempts to prescribe a process for practical use that each individual research project must tailor their use of the grounded theory approach to the requirements of the empirical context. The nature of this research, due to the lack of previous understanding of the innovation process within this context, is best suited to a process that is guided by the principles and tools and techniques outlined within this section.

4.5.2 Review of software within research

The practicalities of handling and analysing large quantities of unstructured data within a sensible time- frame, presents qualitative researchers with considerable difficulties (Dainty et al, 2003). Morrison and Moir (1998) argued that the time spent implementing methods such as grounded theory within research potentially poses considerable problems for the overall time management needs of the research project. Webb (1999) argues that this also leads to a reduction of data analysis as the time is spent predominately on the process of handling it. As a method, the grounded theory process is a sophisticated and complex process requiring a high degree of flexibility and fluidity in order to satisfy the principles of saturation. The consequence of handling data in compliance with these requirements, and in line with the principles highlighted in the previous section, can be described as labour intensive and time consuming (Kelle, 2004). The coding of documents (transcripts), the analysis of coding results and the creation of categories and theory, is a process that, by its nature, is time consuming and awkward from a logistical point of view. The difficulty of being able to manage the grounded theory process is increased when handling large samples of unstructured complex data (Webb, 1999).

Over the past 15 years the use of computer software packages have been employed increasingly as a potential solution to managing this problem (Morison and Moir, 1998). Many researchers such as Kelle (2004) and Silverman (2003) have targeted computer software packages as supplying the potential to dramatically increase the ability of researchers to handle substantial amounts of unstructured data whilst conducting grounded theory analysis. Morrison and Moir (1998) point to the observations of Greson (1984) who suggested that the principal benefit of computer technology is it's potential for increased rigour in the analysis. He highlights the importance of freeing up time and energy of the researcher to think creatively. He along with Webb (1999) agrees that the shift in balance from time spent on the mechanics of data handling towards data analysis is achieved through the software's ability to speed up the clerical tasks involved in searching and retrieving data. Webb (1999) observed that the use of software within qualitative analysis began with great optimism as it was felt that it would add to the objective nature and systematic nature of the process allowing for a more trustworthy, transparent and rigorous approach to the research.

Webb (1999) identified that the software packages available are strongly influenced by grounded theory and focus on the principles of coding within their format structures. As a result packages (both NUD.IST and Nvivo) stylistically and in terms of procedure take the researcher through the steps and tools outlined by Strauss and Corbin (1998) of open coding (development of concepts), identification of dimensions or attributes of categories, axial coding (relationships found between categories and codes), selective coding (is done to identify the most important or core category with which other categories are linked) and theory building stage (researcher makes constant comparisons between codes and identifies links between them assisted by the process of writing memo's, and drawing diagrams to illustrate the developing theory). Such a process would have brought concerns from traditionalists of grounded theory such as Glaser (1992), for the potential dangers of applying a procedural approach to the process. The fact that the software takes the user through the use of these tools in sequence, has the potential to restrict the reflective capabilities of a researcher who doesn't understand the principles that grounded theory is founded. It is important that the use of software is conducted for the correct reasons and its implications are fully understood, and not simply applied for the sake of its use.

The likes of Morison and Moir (1998) are increasingly calling for researchers intending to use software to aid qualitative analysis, to consider carefully the consequences of their decision and to be aware that the use of such programs can alter the nature of the analytical process in unexpected and perhaps unwanted ways. The previous section warned of the potential danger of over prescribing the procedure of the grounded theory process in a manner that restricts the ability of the theory to emerge. Glaser (1990) stressed the need to retain the philosophy behind the principles of grounded theory during the process of analysis. It is clear within the literature that one of the main concerns relating to the use of software is that it presents an increased risk of unknowingly neglecting these principles. Becker (1993) (cited by Morrison and Moir, 1998) argued that using the software for grounded theory data analysis results in flat and over simplified descriptive results. Concern exists that the use of computer software has the potential to stifle the creativity of the process involved in inductive analysis (Morison and Moir, 1998), and that the researcher may actually not notice the manner to which the computer influences the process and findings. Indeed the principle concern relating to the use of software for the analysis of grounded theory relates to how the researcher perceives or unwearyingly uses the software for theory generation.

Under the principles of grounded theory outlined by Glaser and Strauss (1967), Webb (1999) argues that software should not influence or make the conceptual connections or generation of the theory. The role of the software is strictly for freeing up the researchers time through the speeding up of the clerical tasks associated with data handling, in order that the researcher can dedicate more time to making conceptual connections and theory generations. The computer software package has the potential to draw the researcher into literally a programmatic type of data analysis based upon the systematisation of the research process (Morison and Moir, 1998). Interpreting the principles of Glaser and Strauss (1967), the use of the software should not act as a method of assisting in the active analytical process involved in making connections and attending to meaning and representations to the data. Webb (1999) highlights that this is the function of the researcher and it is vital that the process retains the fluidity necessary for creativity. Morrison and Moir (1998) argue that this element has the potential to be reduced due to the rigidity and increased emphasis on procedure provided by the software.

The contextual nature of the data is something that is vital to the process of grounded theory. Webb (1999) argues strongly that on- screen coding can lead to fragmentation and decontextualisation, with the potential to restrict the research to snap shots as opposed to retaining the necessary context for effective analysis. The need to retain the context of the research is also affected by the increased potential that the use of software has on the imposition of a hierarchical structure for the coding process. This can unnecessarily structure data in a manner that distorts the reality of the context. Webb (1999) also argues about the need for the researcher to work with codes within the context of the text, and observes that it is apparent that the use of software can increase the chances of working with the codes in isolation of the text. There is a need when using software to retain the familiarity of the researcher with the data. This problem has been noted to result in concepts being developed based out- with the realties of the data context.

The dangers of prescribing codes for use are also increased with the use of software, due to its ability to search key words. Webb (1999) argues that for grounded theory this is a particular danger as it can result in imposing theory on the data. Kelle (2004) argues that when coding this can be overcome if the use of the software is viewed as a process of labelling for interpretation within the context of the situation and the other codes produced, and not as a mechanical process for labelling.

Webb (1999) argues that the 'use of software should be used as a mechanical tool and not seen as a monster which takes over the analysis'. The researcher is the creative and thinking part of the process and requires to control its use by observing the dangers discussed above. Webb (1999) argues that the dangers of misrepresenting the data though the use of this method results in a situation where only those with a developed understanding of the grounded theory process should attempt to use the software. She also argues that such software should only be used for large data samples, as for smaller samples the manual method remains the most effective.

Despite the reservations regarding the use of software, the popularity of its use has increased steadily and is matched by the development of the software's sophistication. Webb (1999) described the potential benefits that the use of software offers for the clerical tasks of the process. Strauss and Corbin (1998) traditionally described the manual approach to the grounded theory process as involving lots of pieces of paper and a range of different stationary using a series of colours and symbols to represent the developing codes within the data (transcript). This is recognised as a messy process with considerable time spent on transposing information from one sheet of paper to the next. The use of the software automates these activities, allowing easy changes, and the automatic linkages between coded information. This has implications for the storage and ability to manipulate the data. The use of multiple screens allows speed to be developed when coding on screen with the ability for the researcher to flick back and forward instantaneously. The potential in a large sample for saving time and effort through the automation offered for such clerical tasks, presents the opportunity for emphasis to be placed on the analysis as opposed to the clerical aspects of the process. The potential through using the software for tracking coded information and for assessing patterns within large data sets easily, offers great potential for advancing the capabilities of the process and its analysis. Webb (1999) suggested that the increased ability of the researcher to effectively handle the data within the process allowed for the potential to increase the size of the empirical sample. The software as a database provides the capability to handle complex data sets, from any number of case studies and allows for effective cross comparison across a number of different levels and concepts. The use of the software presents benefits within large research projects, by allowing multiple accesses to different users.

The potential exists for using software packages to benefit grounded theory analysis; however, it is clear that this potential can only be satisfied through the observation of the need to retain the principles of the method during the process. Within the discipline of construction management, there has been a growth in the use of both qualitative analysis and grounded theory within research as the industry begins to address a neglect of the softer management issues facing industry. The use of software with grounded theory to assist this process has been noted also within the last few years with research by Dainty et al (2000), Carter and Fortune (2003) and Hunter and Kelly (2003) actively using it as a method. Within these papers, the software has proved to be both beneficial and troublesome at the same time; however, the potential exists to develop its use further.

There are two principle types of software used with reference to qualitative analysis, NUD.IST (renamed N6) and Nvivo. On the market, there exist several different versions of each of these packages reflective of the advanced nature of their development and also the nature of their target audience. Prior to the emergence of Nvivo; NUDI.ST was the format that was used with reference to grounded theory. The use of this package encountered many of the problems and concerns highlighted within this section regarding the lack of fluidity and capability for reflection within the process. The developers of the software (QSR) recognised this and launched Nvivo in order to counter some of these issues. Nvivo has the potential for greater interaction between coding and the text, and a much-increased capability for modelling and graphic representation. The latest versions of the two types of packages have seen NUD.IST or N6 package focus towards being a rapid and robust package designed for large-scale projects. This package focuses on the improvement of the clerical aspects of qualitative research. Nvivo on the other hand is designed as a process to reflect the complexity of the data, and allow the researcher to combine subtle coding with the process of linking, searching and modelling. The distinction between the two packages makes it clear within the context of grounded theory that Nvivo is the most suitable for use within this research, and that through its evolution, the concerns of Glaser (1992) are being observed within its development.

Nvivo as a package provides the opportunity for attributes to be assigned to both the codes and the document, which allows for the context of both to be retained throughout the process, whilst at the same time enhancing the capability for comparison. The reduced emphasis placed on the process as a series of steps, enhances the ability of the researcher to be reflective and fluid within the process. However, it is necessary to observe that just because the package lends itself to aiding the principles of grounded theory, does not necessarily mean that the researcher will. This research aims to use the Nvivo package to aid the grounded theory process, as despite all the concerns regarding the use of software, the potential that it can offer to the research process appear beneficial.

4.6 The case study approach

This section aims to outline the case for using the case study approach within the research project, identifying its suitability for assessing the complex nature of innovation management within the project environment. The discussion aims to outline that the use of case studies within research forms the empirical base of the post modernist research framework and particularly the use of the grounded theory approach. This section will discuss the characteristics of the case study approach, assess the alternatives to its use, and lay out the stages of developing a case study, prior to outlining the use of the approach within the context of this research.

4.6.1 The use of case studies

The disciplines of sociology have adopted the use of the case study approach within its research as a method of scientific enquiry with the 'aim of studying in an open and flexible manner social action in its natural setting as it takes place in the form of interaction or communication and as interpreted by the respondents' (Sarantakos, 1998). Yin (2003) has argued however, that such an approach has been viewed as a weak sibling of social science methods and that it enjoys a stereotype of being of insufficient precision, objectivity or rigor. Such criticism is associated commonly with the post-modernist framework and the use of the grounded theory approach. The case study approach forms the empirical base of the post modernist framework, and modernists traditionally believe that the use of this approach lacks structure and rigor. However, the potential provided for allowing an understanding to develop of complex situations through its emergence from the empirical context of the case study, provides relevance for this research. Yin (2003) and Sarantakos (1998) both argue that case studies are a valid form of inquiry in the 'context of descriptive as well as evaluative and causal studies, particularly when the research context is too complex for survey studies or empirical strategies, and when the researcher is interested in the structure, process and outcomes of a single unit' (Sarantakos, 1998). The level of complexity within this research, in addition to the need to allow the theory to emerge using grounded theory, requires that a case study approach be considered.

Sarantakos (1998) identified five characteristics that separated the case study approach from other types of research, 1) it studies units in their entirety, 2) employs several methods primarily to avoid or prevent errors and distortions, 3) often studies as single units, 4) perceives the respondent as an expert not just a source of data, and 5) it studies a typical case. Yin (2003) supports this by defining a case study as 'an empirical inquiry that investigates a contemporary phenomenon within its real- life context when the boundaries between phenomenon and context are not clearly evident, in which multiple sources of evidence are used'. Sarantakos's (1998) characteristics and Yin's (2003) definition describes an approach that would address the methodology concerns presented throughout this chapter. The case study approach allows complexity to be assessed and understood within the realties of the context that it occurs. The lack of existing research into innovation within the construction project environment produces a need for an approach that allows for an assessment of real- life examples in order that theory can emerge from the realities of the context. The use of a case study approach compliments the conceptual requirements of grounded theory, by retaining the context of both the respondents and the nature of the environment within which they operate. The nature of grounded theory involves the analysis of real-life situations for the benefit of generating theory, and the case study approach compliments this objective.

The alternative to the case study approach is to adopt an industry wide approach, and to look for patterns and observations from a cross section of the industry. Such a sample within this research through either interviews or a questionnaire survey would fail to provide the sufficient depth of understanding of the processes and influences both within the structural and cultural environments of a construction project. Such a methodology would expose the research to unacceptable levels of generalisations relating to the patterns identified, therefore running the risk of stereotyping and categorising the nature of the problems facing construction. The unique nature of every construction project as an empirical basis for observing the innovation process means that making generalisations from industry wide surveys would fail to engage with the realities of the project context. To understand and explore the situation concerning innovation at the project level, an approach that allows the dynamic environment of a construction project to be understood is required.

Industry wide surveys, whether interview or questionnaire based, suffer from problems relating to the representative nature of the sample. Opinion surveys can be useful in identifying trends, however they lack the rigour of an understanding developed within specific empirical real life examples. Whilst the trends can be useful, due to the lack of established knowledge concerning the research context and the uniqueness of the individual project environment, a more detailed investigation is required.

Poor response rates are a recognised problem within any questionnaire survey and issues relating to the validity of levels of response are constantly debated within the research community (Keats, 2000). It is possible to argue that the value of general opinion surveys is not helpful when attempting to understand the complexities and dynamics of the research area. There is also a problem during general surveys over who within organisations to speak to, as different opinions may exist depending on their level of involvement within construction projects.

A case- study allows for a focused piece of research, allowing the researcher to analyse the innovation process and its existence within the context of a construction project environment. This allows for the development of a deep level of understanding of the particularities of a specific project. The construction project environment lends itself to case study analysis through the natural boundaries that it exists. Case studies offer the opportunity to identify patterns and trends within the context of a real life project, by allowing the theory to emerge from the context of its practical appearance.

The case study approach under Yin's (2003) definition can appear as either a singular assessment, or an assessment of multiple case studies. Within the context of this research, due to the uniqueness of each project environment and the identification of both the innovation and project attributes within the previous chapter, a multiple case study approach is selected. Recognition that every project is different and is exposed to a unique set of strategic, structural and cultural problems requires recognition within the approach selected. A multiple case study approach provides the opportunity to assess for general patterns and observations across the range of case studies in the sample, whilst retaining the individual context of each case study. Within this research, the establishment of a generic understanding can only be developed effectively if sufficient examples of projects assessed in sufficient depth are selected as case studies to account for the variations of each of the attributes identified. Research of this nature needs to balance the importance of the specifics existing within singular projects, with the general observations occurring across projects. The ability to appreciate the wider context of specific empirical examples allows for an assessment of the existence of a wider pattern.

The selection of the case studies representing different aspects of reality such as this can be referred to as theoretical sampling (Flick et al, 2004). Gummensson (2000) argues that when using a single case study, 'this provides a general conceptual category or property, a few more case studies can confirm that indication.' The number of case studies adopted in such an approach is governed by the principles of saturation and not by a particular scientific number. The number of case studies is not so important, but rather the quality and level of understanding of these case studies that can be achieved. Within the context of this research the level of saturation will be achieved through the satisfaction of understanding of the attributes that reflect the variations in the characteristics of both the innovation and the project.

Yin (2003) identified three important stages for the development of the case study approach as a method, 1) define and design, 2) prepare, collect and analyse and 3) analyse and conclude. Within the context of this research, the three stages will be governed by the principles and methods adopted using the grounded theory approach. Within the context of a multiple case study approach, these stages require to be considered both within the context of the individual project and across them all for comparison. The use of grounded theory with the use of a multiple case study assessment as an approach will allow the theory to emerge within the context of practical examples of managing innovation within the project environment.

Due to the existence of innovation as a process, the research intends to follow live examples of managing innovation within active construction projects. Huber and Van de Ven (1995) identified the longitudinal approach as the best manner of achieving such an objective. This approach involves the researcher following the innovation over the course of its existence within an active project. This allows the researcher to gain a detailed understanding of the nature of the innovation process and places it very much within the context of the project. By conducting the research over the course of a live project and innovation process, it is possible to observe the context of the management requirements for the process at the time of their occurrence. Without this level of understanding of the environmental factors within a project, it is difficult to fully understand the root causes behind such concerns. The longitudinal approach conducted over a number of individual projects provides a format for comparison, whether relating to the nature of the process of innovation, but also its relationship and interaction with the project environment that retains the principles of the post modernist framework outlined within this chapter.

4.7 Overview of research methodology

The adoption of a qualitative approach using grounded theory to analyse empirically based case studies within a post modernist framework is a methodology that has the capability to engage with the complexity and dynamics of the chosen research area. However, there is a need within the research to ensure that the principles to which the methodology is founded are carefully observed throughout, to ensure that the findings are an accurate representation of the reality. This discussion provides an overview of the research methodology split into three areas of discussion, 1) data collection, 2) coding and category formulation, and 3) theory generation. The nature of this discussion reflects the three main stages of the grounded theory process.

- **Data collection**

The selection of a case study approach within the research requires consideration to be placed on the nature of the sample and the requirements of its selection. The previous chapter outlined both the innovation and project attributes, and consideration of their influence is required in order to make a generic assessment. Within the empirical sample, it is necessary to assess the significance of attributes relating to the existence of the innovation concept within the environment, and the nature of the project environment. The selection of a range of case studies displaying a mix of attributes for effective comparison within the research process is sought. The need to contrast the influence of the different attributes is required in order to assess whether it is possible to produce a generic understanding of the process, and to account for a differing number of attributes.

As outlined in the previous section the number of case studies selected for consideration within the research will be determined under the principles of theoretical saturation. Saturation is a term discussed by the likes of Strauss and Corbin (1998) as being the point within the analysis process where the inclusion of additional data (i.e. case studies) would not add to or alter the findings of the research. Within this context, the selection of the case studies aims to provide a representative sample by covering all of the variations in the form of the attributes for both the innovation and the project environment. An assessment is conducted following analysis as to whether the sample has satisfied the principles of saturation.

The projects were selected with the aid of local contacts, and the M4I (newly named Construction Excellence) demonstration projects. This forum is funded and promoted by the U.K. government in an attempt to encourage construction organisations to share knowledge of innovations and allow potential benefits and problems to be discussed freely. It was anticipated, that since the projects demonstrated within this forum are claiming to be innovative in some manner and are actively advertising this element in a public forum, that the potential exists to encourage participation from them in this research project.

Interviews formed the primary source of data for the research and were structured in accordance with the needs of grounded theory and the contextual requirements of the case- study. The selection of a case study approach determines that the individuals interviewed are those within the construction project who are connected, involved or affected by the innovation process. As a result, when comparing the members of the projects interviewed across the case studies, there is potential for the composition of those interviewees to differ in both position within the project and quantity. A scientific number in no way governs the number of interviews required per case study; this was determined rather by saturation (point when satisfaction is reached, that any more interviews would not add anything to the findings) and the number of those involved in the process. For example, it is possible for one case study to involve interviewing up to twelve individuals and another only requiring four. It is necessary to interview as many of the members involved in the process deemed necessary by the principles of saturation, as different individuals will enjoy a contrasting level of interaction in the process and enjoy an alternative perspective of its progress. This provides an informed perspective of the process, as well as allowing the process to be viewed without bias, which can be problematic when interviewing only one individual. Individuals' opinions contrast with each, and to engage with such opinions provides a true representation of the process. The aim of the interview approach within the case studies is to interact with a live project longitudinally as it happens and allow data gathering to be based on the realities of the situation, in order to avoid problems of bias and memory problems from the respondents.

The longitudinal approach was selected for adoption in order to capture the realities of the project environment as it occurred as a live project. The case studies traced the innovation process over the course of its lifespan within the project environment. Interviews with the project team were staggered over the process, with a series of follow up interviews conducted with the members at the end of the process to assess for changes of opinion and circumstances. The staggering of interviews across the innovation process allowed issues drawn out to be observed in the context to which they occurred, and provided the opportunity for balance when making conclusions. Following the analysis of the transcripts, using grounded theory, key members of the team were revisited to present the findings for comment. This process allows for verification, and for modification.

- **Coding and category formulation**

This chapter outlined that within this research, the nature of the grounded theory process will evolve in relation to the nature and needs of the empirical sample. The process was founded on the principles guiding the approach laid out by Glaser and Strauss (1967), and adopted the tools for coding as described by Strauss and Corbin (1998). The following chapter will outline the nature of the grounded theory process used within this research, however it is necessary at this stage to stress the need to retain the fluidity of the process and to reject the need for an established procedure during the process of coding and category formulation.

Each interview was coded independently, prior to being placed within the context of the remainder of the project team to generate conceptual categories and connections representing the innovation process within that project. The adoption of an evolving fluid process using open, axial and selective coding, with continual feedback between the coding and categorisation phases of the process until the point of saturation is reached. Saturation was reached when the researcher was satisfied that additional coding or category manipulation had no impact on the findings. The research then placed the concepts and theoretical understandings of the individual projects within the context of all of the case studies, and contrasted their differences in relation to each of the attributes to assess for the potential for producing a generic model and understanding.

This chapter has discussed the potential for using software to aid in the assistance of this aspect of the grounded theory process. In order to assess the potential for using the software within the research, two of the case studies were analysed using both a manual approach and the use of the software. The basis of this comparison allowed for the process of using grounded theory to be practiced and understood, and the ability to assess the suitability of the software for the sample at hand. The use of software during the analysis of the data sample had the potential to allow the research to assess the attributes of the projects and increased the potential to compare and contrast their influence.

- **Theory generation**

This research aims to ask the question as to whether it is possible to understand innovation generically within construction projects, and the findings of this assessment will determine whether a generic set of management success factors can be produced. An assessment of the findings within the context of the attributes of the innovation and the project, requires a cross comparison to be made across all of the case studies each of the attributes factors and an assessment of their influence to be made. It is apparent such an approach may generate a series of different models which maybe more appropriate than a singular generic model.

A necessary aspect of theory generation is the process of verification. This is an aspect of any grounded theory process, as it ensures the completeness of the research and the validity of its findings. The process within this context involves the comparison of the findings within this research (i.e. the model, the success factors and the theoretical understandings of the innovation concept and its interaction with the project environment) with the established literature. The generation of the theory requires to assess for aspects that are missed during the grounded theory process as well as highlighting important differences and similarities between the research and established thinking. This provides the necessary theoretical justification for the findings of the research.

The research methodology within this research requires to be adaptive and flexible within its approach in order to adapt to the needs of the emergent nature of the grounded theory method. The methodology also requires to be responsive to the needs of the sample. Chapter 5 discusses the practical experience of the implementation of the use of these approaches within the research.

Chapter 5

5 The practical experience of model building using grounded theory

5.1 Introduction

This chapter aims to provide a review of the practical implications of adopting the methodology outlined within the previous chapter. The first section will review the methodology in practice, outlining both the nature of the process and the results of the comparison of the manual approach and the use of the software during the grounded theory analysis. The second section provides a review of the practical selection criteria for the case studies.

5.2 Review of the methodology's use in practice

The methodology chapter outlined the decision for this research to observe the principles of grounded theory during its implementation, and highlighted the potentially resulting difficulty and time-consuming nature of the process. This section highlights the nature of the grounded theory process adopted within the context of this research, illustrating that every example of the implementation of the grounded theory approach requires the process to be tailored to the requirements of its sample. The results of the comparison between manual and software methods for grounded theory analysis will be discussed and the case for using the software will be provided.

5.2.1 Stages of the process of model building

The previous chapter identified the need to tailor the principles of Glaser and Strauss (1967) and the tools identified by Strauss and Corbin (1998), in a process that is reflective of the context to which it is placed. In order to ensure the findings of the analysis are representative of the sample, there is a requirement for the grounded theory process to maintain the fluidity and flexibility to observe the principles of reflection and engagement outlined by Glaser (1992). Strauss and Corbin (1990) were criticised for producing a process that lacked these principles, in their attempt to layout a process for the practical benefit of assisting others' understanding. Glaser (1992) argued that the dangers of over prescribing the process endangered the emerging nature of the approach. The process adopted within this research avoids this through use of the principles of saturation during each of the phases of the analysis. Each phase of the process is made up of a series of activities operating in a fluid manner with each other, with activities continually revisited until saturation has been reached. The nature of this process aims to avoid the criticism of producing a prescribed process, which was formally structured.

Figure 5.1 displays the grounded theory process adopted within this research. This model differs from many examples in that it makes a deliberate attempt to visibly recognise the interactive and interdependent nature of each of the activities within the process, by using feedback loops. Examples such as Strauss and Corbin (1998) and Al-Saedan (2004) describe a process that simply displays a sequence of activity boxes, operating in sequence with no feedback contained between the individual activities. One large feedback loop is traditionally included at the end of the process to represent the failure of the process to reach a saturation point and signifies the need to start the process again. This approach fails to recognise the interactive nature of the method, and the need to achieve feedback and re-evaluation throughout, and not only at the end of the process. Activities require to occur in conjunction with other activities within the

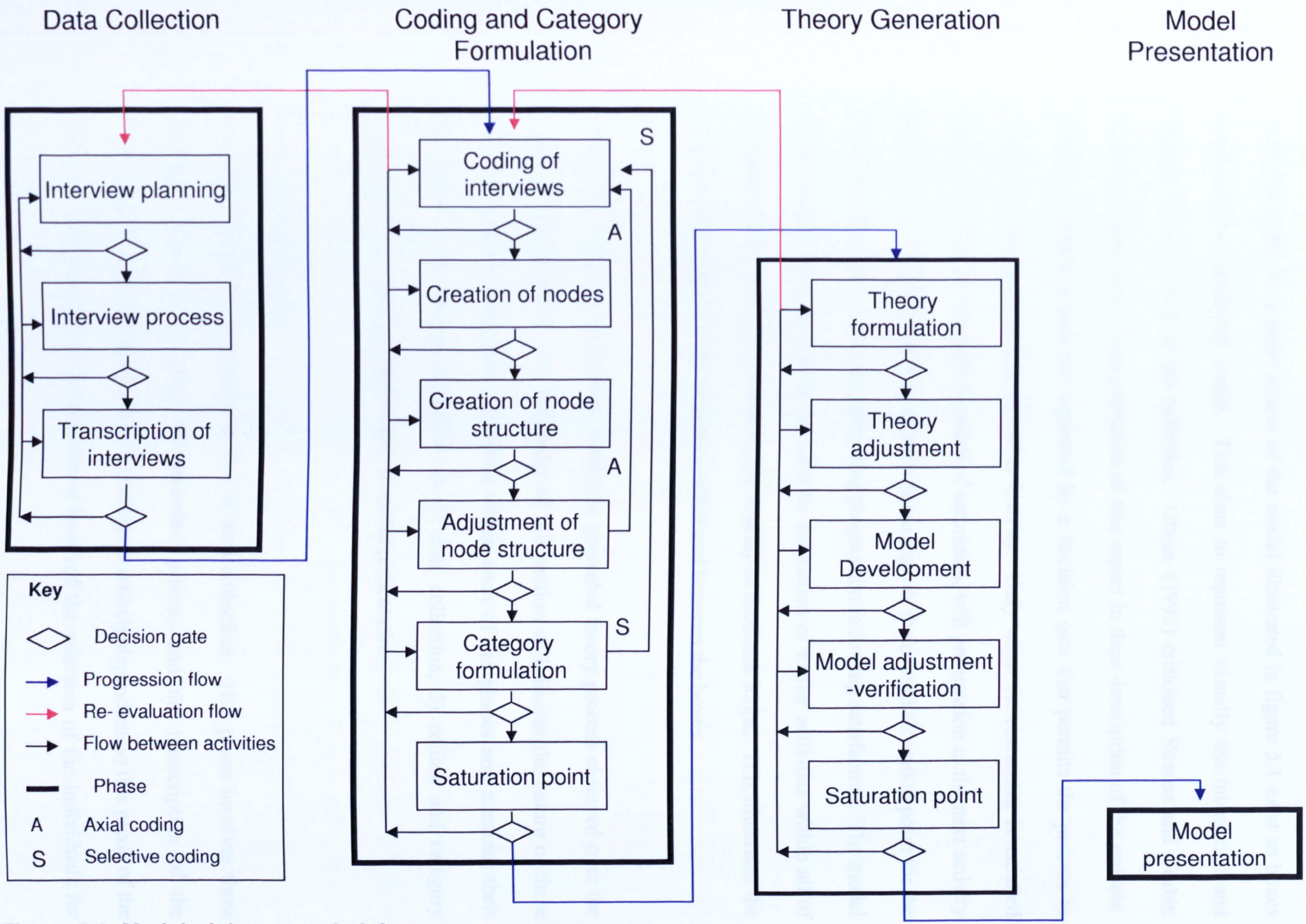


Figure 5.1: Model of the grounded theory process

process, as changes made within one will have repercussions on the findings of another. As a result, the three main phases of the model illustrated in figure 5.1 exist as boxes with activities displayed inside. This aims to represent visually the interaction and fluidity between each of the activities. Glaser (1992) criticised Strauss and Corbin (1990) for their lack of representation of this aspect in their description of the process. The individual activities are separated by a decision gate that permits the process to continue or to feedback into an earlier activity. Only when the researcher is satisfied that the activity has reached the point of saturation, will progression to the next activity be permitted. The final activity of each phase regards the overall saturation point for the activities of the phase, as only permitting progression following satisfaction. The model acknowledges the need for the constant re- evaluation of earlier activities within all of the phases throughout the process by the display of feedback loops. This illustrates the flexibility and fluidity of the activities within and between the boxes.

The model identifies four phases within the grounded theory process observed over the course of the research. The remainder of this section will discuss the nature of these phases, outline the activities identified within each of the phases and consider their interaction. The phases identified are 1) data collection, 2) coding and category formulation, 3) theory generation and 4) model presentation.

1. Data collection

The initial phase of the process is that of data collection. This phase involves three activities, interview planning, the interview process and the transcription of the interviews. The overall quality of the findings is entirely dependent on this phase of the process. The planning of the interviews involved the selection of the individuals for interview and arranging their participation at a time appropriate within the project/ innovation process. The interviews were designed to be semi- structured in format and extremely open in style. The appendix (A) contains a copy of the interview structure, illustrating the nature of the structure of the questions which lend themselves to open and responsive discussions. The interviews were recorded and transcribed word for word in order that full representation of the discussion was obtained. The context of the interview was carefully observed by the researcher in order to maintain the context behind the responses. Each activity operated on the principle of saturation, with progress to the next activity only permitted when the researcher was satisfied that nothing more can be done at that point. This is represented by the use of decision gates following each activity. There is scope for this decision to be revisited should changes occur later in the phase. Only once the researcher was satisfied that all three activities had reached saturation point was progression to the next phase of the process permitted.

2. Coding and category formulation

The next phase is the coding and category formulation phase of the process. The coding of the interviews was the first activity of this phase, and involved going through the interview transcript and coding the information through the process of highlighting. Initially this was conducted using the tool outlined by Strauss and Corbin (1998) of open coding, with coding occurring under no established criteria, with patterns discovered within the data. Once the saturation point was reached for this activity and no further codes were assessed as emerging from the data, the activity of creating nodes occurred. Nodes by definition are the 'containers' to which the codes are placed (Webb, 1999). Nodes are initial working groupings of codes for handling purposes, as relationships between them are investigated and established. This occurred freely initially, prior to the emergence of a hierarchy structure for the nodes that assisted in the assessment for patterns and relationships. These three activities required constant interaction between each other, and represented a period of high creativity, as the researcher attempted to make sense of the coded material under the principles of conceptual emergence and saturation.

The adjustment of the node structure followed these initial activities, and at this point, the tool of axial coding identified by Strauss and Corbin (1998) was deployed, and through its use, the first three activities were reconsidered. Axial coding is the activity of investigating nodes further and developing sub- nodes around the axis of the central node. This involved the process of revisiting the transcript and searching for codes that will develop the emerging individual series of nodes further to provide the process with a direction of focus. Once satisfaction was reached regarding the saturation of this activity, the activity of category formulation began in order to develop the shape of the research findings through its display as categories. The tool of selective coding (Strauss and Corbin, 1998) was deployed at this point in order to develop the depth of each of the categories and assess for codes previously missed. Selective coding is defined as the process of integrating and refining the theory, through the coding of the transcript guided by the formulation of the categories. Each of these activities was continually revisited until saturation was reached, both individually and as a phase as a whole.

In addition, the revisiting of the first phase of the process occurred at numerous occasions, as patterns emerged during this phase required further investigation during the interview process. This emphasised the need for an interactive process that constantly revisited previous activities, in order to adapt the process in line with the findings.

These tools and activities were the same as those described by Strauss and Corbin (1998). However, their description failed to place sufficient emphasis on the principles of saturation and its implications for re- evaluation and fluidity between the activities. The emphasis placed on the principles of saturation within this research, allows the process to retain its fluidity and retain the emergence of the theory from the data. These are principles that Strauss and Corbin (1998) failed to emphasis during their description of the coding and category formulation phase of the grounded theory process. Although, Glaser (1990) acknowledged in his criticism that they would have employed these principles within their own use of the process, he cited that the danger exists that other practitioners following their process may not due to its lack of emphasis. This research has attempted to display the use of a grounded theory process that remains tied to the Glaser and Strauss (1967) founding principles, whilst at the same time employing a more practical approach in line with Strauss and Corbin (1998), particularly within the context of this phase.

3. Theory generation

The third phase of the process is the theory generation phase. The phase involved the activities of theory formulation, theory adjustment (through testing), the development of a model, the verification of the model and subsequent adjustment. Structurally this phase involved activities that interact with each other in the same manner as within the previous phase, by using decision gates assessing saturation, and the resultant progression and re- evaluation flows emanating from this. The activity of theory formulation took the categories generated within the previous phase and aimed to develop an understanding and logic behind their formulation. Once saturation was reached, the theory was then adjusted through its re- evaluation within the context of the data.

When completed these two activities present the opportunity for the development of the model. At this point, the model should emerge from the theory without outside influence, and within this research the emergence of a phased process model was evident from as early as the category formulation activities within the previous phase (however this may not always be the case). The model was verified through the consideration and testing of the model against the coding and categories emerging from the previous phase for its validity, and allowed for adjustments to be made. Input was provided from someone close to the situation (i.e. a member of the project team) to assess their reaction to the model and their interpretation of its representative nature. In addition to this, the theory and model were assessed against established theory and models in order to complete this assessment. This allowed a comparison to be made, and the nature of the context of the research to be appreciated fully. Only after the researcher felt that the theory and the model had reached a point of saturation was it ready for presentation.

4. Model presentation

The fourth phase of the grounded theory process, involved the presentation of the model and theory, and this involved an assessment of the most appropriate manner in which to package the findings of both the model and its implications. Within this research, the foundations of the model were established following the previous phase, but the emergence and implications of the success factors required development in order to present their implications for maximum practical affect. The findings of this activity are presented in chapter 10.

- Consideration of the attributes during analysis

The nature of each of the innovation and project attributes was considered within the analysis process. The potential for producing a generic model representative of all of the aspects of the attributes was examined. The research was careful not to assume that a generic model and understanding exists, and to constantly consider the possibility that a number of different models may be required.

5.2.2 Use of software within grounded theory process

The previous chapter highlighted the decision to explore the potential of using software to aid the grounded theory process. It was concluded that despite the reservations within the literature relating to its use, the potential benefits and opportunities that it offers are clearly worthy of investigation in practice. A pilot study was conducted using two of the case studies and analysis performed using firstly a manual approach and secondly the use of the Nvivo software. The assessment was based primarily on a comparison of each approach to handle the data, whilst retaining the principles of the grounded theory process. In addition to providing an assessment of the potential for using the software, the pilot allowed the researcher experience of the grounded theory process in a practical sense enabling for potential improvements. This section will firstly discuss the implications of the pilot case studies on data collection (a phase that remains the same when using either a manual or software approach), prior to discussing the remainder of the grounded theory process through a comparison of both the manual and software approaches.

1. Data collection

The pilot study was designed to assess the development of the data collection phase of the research process, in addition to the analysis techniques deployed. During the first case study, it was noted that the length of time taken to transcribe the interviews would if conducted by the researcher dramatically shorten the time available for analysis. Due to the open nature of the interviews, the duration of an interview on many cases exceeded one and a half hours. Due to the size of the sample it was necessary to find a trained secretary to perform this procedure. This was recognised early within the research and potentially saved considerable research time overall. During the pilot, the interview planning and process was reviewed continually in order to refine it to achieve the best quality of data possible within the context. The use of grounded theory lends itself naturally to continue the reflection of this phase, as the principles of the theory encourages questioning of the data collection process and promotes assessments of how to improve it.

2. Coding and category formulation

The data collection phase is not affected by whether the process is preformed by manual methods or by the software, but it is the coding and category formulation phase of the process where the differences between the two approaches are noted. The discussion addresses two aspects of this phase where differences were evident, the activity of coding and the wider aspects of data handling.

a) Activity of coding

The coding procedure of an interview differed considerably when using either the manual and software approaches. For the manual approach, this process involved the highlighting and underlining of codes on the transcript. This posed problems, as it was difficult from a practical point of view to alter decisions regarding a given code and thus reduced flexibility. This was noted by the likes of Webb (1999) and Kelle (2004) to be a persistent problem when using such an approach. The transfer of codes into nodes proved also to be labour intensive. The logistics of referring back and keeping track of the context to which the code was generated was extremely difficult manually. These observations are acknowledged by the likes of Webb (1999) who was concerned at the time-consuming nature and awkwardness of this activity from a logistical point of view.

The pilot revealed the problems experienced when manually handling the coding of interviews in two case studies and although this was still manageable, the process would increase in complexity significantly with more case studies. Webb (1999) discussed the difficulties of managing this activity within large samples of unstructured complex data and pointed to the use of software as increasing the potential of managing this problem.

Although the function and concept behind the coding process was the same in both the manual and software approaches, the pilot found that the ability to conduct the process on- screen when using the software made the process significantly more flexible and automated the transformation of the codes into nodes. This was an observation that Morrison and Moir (1998) identified as reducing the labour intensity of the process by increasing the practical handling capabilities of the activity of coding. It was also observed during the pilot that the development of the node structure automatically whilst actively coding, eased the process of developing patterns. The automation of the clerical tasks during this activity illustrates the potential in practice observed previously by the likes of Webb (1999) and Morrison and Moir (1998). The software's capacity for data storage and the ability of the researcher to interact with the transcript and the nodes simultaneously represented a considerable improvement when compared to the manual method. The flexibility this offers in practice enhanced the reflective capabilities of the process, by improving both the handling of the codes and nodes, and freeing up time within the process for focus on analysis as opposed to simply handling it. This potential was observed by both Webb (1999) and Silverman (2003).

The previous chapter cited that the process of on- screen coding created direct problems during the analysis process of maintaining the context of the interview and its situation. Many traditionalists such as Glaser (1992) pointed to the dangers of following a procedural approach during analysis to the principles of grounded theory, and Morrison and Moir (1998) cast concern with relation to this regarding on- screen coding. However, in practice it was noted that the Nvivo package represented an improvement on previous packages such as NUD.IST and facilitated avoiding this problem through its style and increased focus on flexibility. It was also apparent that the better the understanding and experience of using the grounded theory process and its principles, the lessening of the danger of misrepresentation through the enhancing of the researchers awareness of the significance of the context of the interview and its situation.

In comparison to the manual approach when performing the activities of coding and creating a node structure, the software provided the ability to retain both the context and the ability to be reflective with the transcript through its ability to track concepts observed throughout the grounded theory process, right back to the original code. This is a quality difficult within the manual approach, and although achievable, it was not possible to perform the trace in seconds and in a bigger unmanageable sample.

b) Data handling

Within the pilot, the nature of the activities associated with the creation of the node structure, category formulation, and the ability to manipulate the data in order to reveal the patterns and trends, was noted to contrast heavily between the manual and software approaches.

The use of a manual approach for these activities was achieved at a practical level using pieces of paper representing the individual codes and nodes. During the pilot, this process allowed patterns and linkages to be observed as they were moved around freely on a table creating both categories and a general structure. Whilst conceptually this process allows for the emergence of theory, in practice during the pilot the quantity of nodes created during a single case study made the process difficult and cumbersome. Due to the length and the number of the interviews, and the complexity of the area of concern, the number of nodes became unmanageable. Considerable time and labour was spent solving this problem in practice, thus enabling categories to be created. Given the quantity of other case studies to be used within this research and the serious problems that would be experienced when assessing for a potential generic pattern across them, it was felt impractical as a method to use a manual approach of analysis. In addition to this issue, a difficulty was observed in retaining the context of each individual code during the activity of category formulation. Whilst it is possible to retain the context with time and labour for two case studies, for a multiple case study approach this would prove extremely difficult in practice.

The software approach does not alter the nature and interaction of the activities from a process perspective, but dramatically assists the data- handling components of the process. The problems observed within the pilot relating to the time and labour involved in the manual approach, were not noted within the context of using the software. The cumbersome process described above for the manual approach was replaced by an on- screen process that easier to use and offered greater flexibility in practice. The storage and organisational capabilities of the data with the software made the on- screen activity of searching for patterns and linkages between the nodes visually easier and quicker. The resultant reduction in the time spent on the process allowed for a greater proportion of the researcher's time to be spent relating to the analysis as opposed to the clerical tasks dominating the manual approach, as noted by the likes of Webb (1999) and Morrison and Moir (1998). The ability to reflect on the findings and conclusions within the process in the context of the transcripts (codes and transcripts are linked throughout the process to the nodes and categories) is enhanced considerably using the software approach. Whilst this is possible to a certain extent with the manual approach for two case studies such as within the pilot, for a larger data sample only the software allows for the context to be retained in a manageable manner.

There is a danger because of its ease, when using on- screen coding to over code, and create a level of coding that becomes unmanageable later in the process, particularly when trying to draw conclusions. This is potentially a problem within the context of the manual approach, however the speed and ease to which coding using the software occurs increases the potential for this as a problem. Grounded theory, due to its unstructured nature, lends it self as a process to the dangers of over- coding as the researcher searches for every available aspect of relevance. This urge when using the manual approach is controlled to a certain extent by the time and labour involved, however the use of on- screen coding can lead to a tendency for over coding. This issue was discussed by Webb (1999) and Kelle (2004) and requires consideration in relation to allowing a manageable number of codes to emerge in order to assess their patterns and trends for establishing categories. The value of the pilot was demonstrated, as these lessons were observed in practice and remedied.

The use of software during this phase has been illustrated during the pilot to greatly enhance the capability of the researcher to handle and analyse the data. However, there is a need when using the facilities offered for analysis to retain the principle of grounded theory, as there is the potential to allow the process to be driven by the systematic and procedural appearance of the software approach. This was observed as a potential problem in the previous chapter with practitioners such as Webb (1999), Morison and Moir (1998) and Kelle (2004) citing it as something that is vital to avoid, to ensure the quality of the research. The use of the Nvivo software appears however, to have acknowledged this problem and improved the facilities for interactive comparison within the other activities of the phase. As long as the researcher observed the principles of grounded theory, the conceptual use of the coding and category formulation phase of the process did not change, and the practical implications of using the software improved the effectiveness of the process. The adoption of a manual approach within the pilot reinforced the principles of grounded theory and the nature of the process in practice, prior to adopting the software approach. This level of understanding allowed the researcher to prevent being dictated to by adopting a procedural approach when using the software in practice.

3. Theory generation (including model presentation)

During the pilot, it became clear that the third phase of the process did not benefit to the same extent from the use of the software. It was noted that certainly for the modelling development activities that it was just as easy to conduct this activity manually. Although the Nvivo software package offered the facility for model building, due to the nature and complexity of the findings within this research, this proved to be too simplistic for this purpose. It is possible however that this assessment may be reflective of the user's personality and some individuals may be happier than others to interact with modelling using the software.

Of greater use was the capabilities provided by using the Nvivo software package for assessing the influence of the attributes within this phase. The software offered a facility for testing the attributes connected to the interview transcript against each other and allowed for patterns to be assessed. It was possible to assign attributes to the interview transcript, and for all the codes and nodes associated with this interview to be assigned a fingerprint of attributes allowing for the context of the code and node to be easily assessed when required. Within this context it was possible to assign the individual interviews with the attributes discussed earlier (innovation and project) and to include the additional attribute of the individuals professional position within the team. It was then possible to create assay tables comparing the frequency of nodes or categories assigned to the different attributes, in order to assess the dynamics of the findings. For example, it was possible to assess if leadership was a more important concept for the client than the architect, or that greater resistance to the concept was detected the further down the project hierarchy the team member was positioned.

Depending on the findings, it was possible to extend the sophistication of the search to include a greater number of attributes in the assessment, i.e. system innovation architects cite leadership as a more important factor than both process and component innovation architects. This facility provided the opportunity within the research for multi- attribute consideration of the findings, thus allowing their meaning to be placed directly within the context to which they were found. This process allowed for many of the anomalies detected within the findings to be explained through the ability to relate them to the realities of the situation. Figure 5.2 provides an example of an assay table from the research. The pilot revealed this to be a considerable advantage when dealing with large data samples, and is an activity that could not be conducted manually with the same accuracy and detail. However, despite the obvious potential that this facility offered for multi faceted analysis and comparison, the findings generated required to be considered as purely indicators for influencing theory building and modelling, and could not be viewed solely as conclusive findings. Observing this rule maintained the qualitative nature of the research, and avoided making definitive conclusions based on the interpretation of the software. The pilot revealed the danger of systemising and procedurising the process if used incorrectly, and therefore interpretation needs to be viewed within the wider context of the findings of the process thus retaining Glaser and Strauss's (1967) founding principles. Despite this warning, the pilot illustrated the benefits that this facility can provide to the research.

Scope items	Involvement Sufficient	Involvement Insufficient	Knowledge Sufficient	Knowledge Insufficient	Access to d-m process Sufficient	Access to d-m process Insufficient	Participated in process	Total	Percentage %
Architect	1		1		1		1	4	57.4
Client rep	1		1		1		1	4	57.4
Quantity surveyor	1			1	1		1	4	57.4
Planning supervisor		1		1	1		1	4	57.4
Principle contractor	1			1		1	1	4	57.4
Site manager		1		1	1		1	4	57.4
Total	4	2	2	4	5	1	6		
Percentage	66.67	33.33	33.33	66.67	83.33	16.66	100		

Assay table provides a means of assessing the correlation between the interviews and the nodes. This example illustrates a set of nodes considering issues relating to the participation of the team with the innovation. The display of '1' indicates the node's identification within the interview transcript.

Figure 5.2: Assay table

The selection of the software approach

This section has highlighted within each of the phases of the grounded theory process the experience of using the software approach. The ability to increase the efficiency of the process with relation to coding and data handling presented the research with the opportunity to handle a larger sample and increase the time spent on analysis as opposed to clerical tasks. The principle advantage with relation to data handling that the software provided over the manual approach, is that once the interviews were coded the codes and nodes were stored within the software. The software allows the process to be managed in order that many activities within the process, were not repeated, thus ensuring that repetition for the sake of repetition within the process was avoided. This was noted to be an advantage particularly when re- evaluating previous activities during the process to accommodate changes and alternative pathways of enquiry that emerges in the later phases of the process. The software simply created a new file and transferred the coded interviews to this file, and then the researcher arranged the node structure to suit the needs of the process of analysis. This allowed the following activities within the process to be preformed without influence of the previous attempts. Given the size of the data sample, it was not possible to conduct this activity with ease or quickly with a manual process. A manual approach would find this very difficult, as the process would possibly have to be started again due to the nature of the paper trail.

The opportunity to gain a practical comparison and experience of both methods, proved to be extremely beneficial in both learning the grounded theory process and ensuring that its principles are retained when using the software approach. Glaser (1990) argued that retaining the principles of grounded theory is vital to ensuring the validity of the method. The likes of Webb (1999) and Morison and Moir (1998) expressed concerns relating to the potential damage that using a software approach can cause to these principles if implemented wrongly. Consequently, effectively adopting the principles of grounded theory requires a considerable amount of care and attention, and this is particularly the case when adopting a software approach to aid the process. The pilot reinforced this need and allowed reflection on the methods deployed thus ensuring that this care for the principles is fulfilled.

5.2.3 Implementation of approach

During the implementation of the software within the research, many of the problems noted within the pilot appeared during the process, and therefore required to be continually mitigated against in practice. Although action was taken to limit these problems prior to the start of the process, it was difficult to completely eradicate them from slipping into the process. The value of the pilot was that the researcher was aware of them and was able to react when necessary to remove them. The tendency to over-code was identified within the pilot to be a problem, and despite this presented a significant problem within the research process. The size of the data sample (some 75 interviews spread over nine case studies) proved to require a significant amount of labour to manage the process despite the use of the software. The dangers of over-coding provide in practice to be a considerable problem particularly within the early stages of the process. A decision was taken after difficulties were experienced with the category formulation phase of the process, to scrap the previous coding and to start again as the node structure had become unmanageable. This was noted not to be such a problem thereafter as experience had proved invaluable in judging the process.

For the future, it would be desirable to attempt to utilise more of the modelling capabilities presented by the use of the software. It was observed that some individuals are simply better at developing models with a piece of paper and a pen, and others enjoy the sophistication of using the software's facilities. It was felt that the software did not allow for the complexity of the data to be adequately represented within this example; however, it would be worth investigating a means around this problem for the future.

The grounded theory approach took considerable time to master in practice, and the use of the software added to the need for the learning curve. However, it was recognised that the time and persistence with the process was invaluable and essential to enable the research to retain the quality required.

5.3 Selection of case studies

The previous chapter outlined that the nature and number of case studies selected within this research was not governed by a scientific number, but through the principles of saturation. Under this understanding, the number of case studies is determined by the point when the researcher is satisfied that no additional case studies will alter the nature of the research outcomes. In order to develop a generic understanding and model of the innovation process within this environment, the case studies require to provide a representation of the variations in the form of both the innovation and project attributes. Each case study was multi faceted with relation to its attributes, and a sufficient number of case studies were required in order that an effective comparison of the influence of each attribute and each variation of their form was represented within the sample. The number of case studies was determined by the satisfaction that the form of each of the attributes was represented within the sample and had reached saturation point. Other aspects or attributes identified within the literature review such as management ability and experience were to be assessed within the research process, as they could not be considered at the selection stage. This section will firstly discuss each of the innovation and project attributes identified within the sample, highlighting the difficulties encountered when achieving saturation in practice. This will be followed by a review of the case studies selected and the presentation of a selection grid highlighting the form of each of the attributes for the individual case studies.

Innovation attributes

Chapter 3 outlined that innovation within the construction project environment existed in three attributes, type, scale and source, each varying by form. This discussion will detail the form of each within this research and consider the issue of saturation.

- **Type**

This research identified three different types of innovation existing within the construction project environment, i.e. system, process and component. The selection process aimed to provide representation of each of these types within the case studies. However, it was observed that due to the unique nature of construction projects, even if the case studies exist as the same type, many differences might exist between them. Therefore, a diverse range of case studies was sought for each innovation type. This attempted to maximise the level of comparison between the different types, whilst retaining the representation of the sample. Only by considering different examples of the same type of innovation, were the principles of saturation satisfied.

Three case studies were identified for each of the types of innovation. The selection of nine case studies within the sample was not reached solely to satisfy saturation for this attribute. Instead, this decision was based on consideration of the saturation of all the attributes. The three system case studies were identified as providing examples of the use of partnering as a procurement route within construction projects. It was not the intention to select three case studies sharing the same innovation, and concern was raised initially as to the representativeness of this comparison. However, the case studies represented sufficient differences within their use of the innovation and the nature of the project team to provide an effective forum for comparison. Case study (No 3) illustrated a differing approach to implementing the partnering within the hierarchy of the project, and employed a contractor who provided many roles of the team in- house. The innovation represented a strategic version of partnering operating over five different projects, whereas the other two operated within one project but over a number of different phases. This made the case study different from the other two, and presented an effective comparison. It was observed initially within the analysis that for the purposes of saturation it may have proved beneficial to provide a case study that was not founded on a partnering format and was not tied to the environment of a housing association construction project. However, in practice analysis revealed that this would not alter the nature of the research findings, as saturation for the purposes of this research was reached.

Within both the process and the component innovations case studies, this did not present a problem, as the case studies represent very different examples of that type of innovation. As with the system innovation case studies it is possible to question the type selected to improve the sample, and it was possible to suggest that it would have been beneficial to find a management styled innovation as a component innovation case study to add to the comparison. However, it was considered during analysis that this was not necessary, as it would not affect the nature of the findings.

- **Scale**

Chapter 3 outlined the need to select a range of case studies that were either radical or incremental in their scale to allow for an effective comparison of the influence of this attribute. The scale was assigned by the researcher based on discussions with members of the project team in an attempt to gauge their experience of the innovation and its departure from established practice. Within the sample, four case studies were identified as being incremental in scale, and five that were regarded as radical. The research achieved a balance with scale in relation to the other attributes, allowing for a representative assessment.

The selection of case studies with reference to this attribute was conducted by a subjective judgement of the case studies. During the analysis, it became evident that these assessments would increase in depth, and a measure of scale assigned determined through judgement and not just subjective feeling. Chapter 9 will discuss the evolution of this attribute firstly as an attribute that is representative of the scale the innovation represents to the team, and secondly an attribute that represents the scale of the linkages between the innovation and project processes and the difficulty that this can present to its management. It became apparent however, that such an assessment could only be made following the analysis of the case study, as it requires a level of understanding not available at the time of selection.

- **Source**

The research identified the source of the innovation as an attribute that required investigation as to the extent of its influence. An effective comparison of innovations generated from internal or external sources required to be represented within the selection of the case studies. Understanding whether the processes surrounding creativity and idea acceptance within a team influence the nature of the process and its management requirements needed to be investigated. It was clear from assessing the availability of potential case studies that externally generated innovations were dominant within the construction project environment and that internally generated innovations were found mainly with relation to process innovations. However, despite the difficulties in finding cases studies out with this trend, it was concluded that it was not necessary to search for additional case studies as saturation was achieved without this.

Project attributes

Chapter 3 outlined two project attributes that affected the management of innovation, i.e. management style and funding regime. This discussion will detail form of each within this research and consider the issue of saturation.

- **Management style**

The literature review highlighted the potential significance of this attribute as an influence on the performance of the innovation process within the project environment. Consequently, it was deemed necessary to provide sufficient comparison of the differing nature of this attribute in practice, as it was noted that potentially projects that are multi- party differ from those that are in- house in management status. Three case studies were selected that represented organisational in- house projects. These three were identified to provide a comparison with the temporary multi- party format. This was achieved by drawing comparisons between projects of process and component type. The intention during selection was to provide an in- house system case study; however, in practice this was not required. Case study (3) although multi- party by status was deemed to represent a sufficient comparison to satisfy saturation principles. Although operating in a multi- party project, the contractor performed many of the roles of the project team in- house (i.e. architect, Q.S., along with the onsite management activities) and the team as a whole behaved in the manner of an in- house team as it operated continuously over five projects. As a result, this resulted in an effective comparison of both styles in all three of the types of innovation, in addition to the other attributes and thus satisfying the principles of saturation.

- **Funding regime**

Within the sample there required to exist examples of both privately and publicly funded case studies. As with the previous attribute, it was difficult to find a case study that represented in this context a privately funded system innovation. However, during analysis sufficient room for comparison was available through the selection of the three private projects to satisfy the needs of saturation. There exists a close alignment between in- house projects and privately funded projects, and this relationship will be discussed in chapter 9.

Review of the case studies

Within the appendix (B), there is a summary of each of the case studies, outlining the details of the innovation and the project, and discussing the experience of the management of the innovation as a process within this environment. This provides a context to the nature of the findings presented in the following chapters of the thesis.

Selection grid for case studies

Figure 5.3 provides a selection grid identifying each of the case studies, detailing the form of each of the attributes. The grid displays the nine case studies selected for the sample. The grid highlights the issues identified in the previous discussion, relating to satisfying the form of every attribute when comparing it to other attributes. The most obvious example of this was with relation to comparing the form of other attributes such as the source of the innovation, project management, and political environment to the system innovation type. This could have created problems with relation to saturation conceptually and resulted in additional case studies being required, however it was considered that the dynamics and variation displayed within the three system case studies and the other case studies within the research, overcame this need. The nine case studies identified within this sample are observed to be representative under the principles of saturation to allow generic conclusions to be drawn within this research should they emerge within the analysis, due to the representative nature of each of the attributes identified in chapter 3.

Project	Type of innovation	Scale of innovation	Source of innovation	Project management	Political environment	Specifics of innovation
Case study (1)	System	Incremental	External	Multi- party	Public funding	Partnering (1 project, 4 phases)
Case study (2)	System	Incremental	External	Multi- party	Public funding	Partnering (1 project, 2 phases)
Case study (3)	System	Radical	External	Multi- party	Public funding	Partnering (Strategic, 5 projects)
Wind turbines	Process	Radical	External	In- house	Private funding	Wind turbines
Demolition waste recycling	Process	Radical	Internal	Multi- party	Public funding	Demolition waste recycling
Reed bed gully waste	Process	Radical	Internal	In- house	Private funding	Reed bed treatment plant
Grass Roof	Component	Radical	External	Multi- party	Public funding	Grass roof
Passivent	Component	Incremental	External	Multi- party	Public funding	Ventilation system
Roof insulation material	Component	Incremental	External	In- house	Private funding	Insulation material

Figure 5.3: Selection grid for case studies

Chapter 6

6 The development of a generic innovation process model

6.1 Introduction

The objective of this chapter is to outline the nature of the generic innovation process model emerging from the grounded theory process described in the previous chapter. The chapter will initially describe the structure of the model, to establish the dynamics of the process, prior to presenting a detailed breakdown of the structure by discussing the nature of the individual phases of the model. This discussion will provide the foundation for investigating the wider theoretical and practical implications of managing innovation within the project environment in the remainder of the thesis.

6.2 The generic innovation process model

During the grounded theory analysis, it became apparent that within every case study the management of innovation existed as a linear process with a given lifecycle, requiring management throughout from idea generation through to its termination of use. Failure to recognise this was observed within some of the case studies, and evidence linked this failure with many of the problems noted within those case studies. A comparison of case study (1) and (3) illustrates the impact that failing to manage the process throughout its lifecycle can have on the success of the innovation. Although both were system innovations, and displayed a similar innovation in form, top- level management within case study (1) withdrew from the day-to-day running of the innovation process following its implementation within the case study. Consequently, the innovation lost direction and failed to receive the necessary support and management during the remainder of the process. This evidence illustrated an innovation that drifted and ceased to exist in its planned form following implementation. By contrast case study (3) retained its direction and focus throughout the process due to the continued involvement of all levels of management.

Whilst the concept of a linear process should be expected due to the project nature of the environment, the emergence of three decision gates punctuating this process was a significant observation. Figure 6.1 displays the generic innovation process model, and illustrates the three observed decision gates and the four phases created through their punctuation of the process and the boundaries they mark between them. The analysis revealed that each of the decision gates marked a transition in the nature and function of the activities of the process, with its satisfaction required for progression of the process. Failure to satisfy the decision gates resulted in the previous activities being revisited until progression was granted. Satisfaction was achieved through permission or the authority to progress being granted by those involved within the process. The nature of this authority varied depending on the case study, with some such as the reed bed and wind turbine case studies requiring top- level management authority for progression. This contrasted with the system innovation case studies where a consensual authority from the entire team was required. This reflects the nature of the innovation's emergence within the team as both the reed bed and wind turbine case studies represent examples of bottom- up innovation (where the innovation emerges from within the project team) and the system case studies representing top- down innovation (where the innovation emerges from top level management). Regardless of the nature of the flow of authority, there is a need to represent these decision gates within the process. The decision gates act as thresholds, and in a linear process act as boundaries between

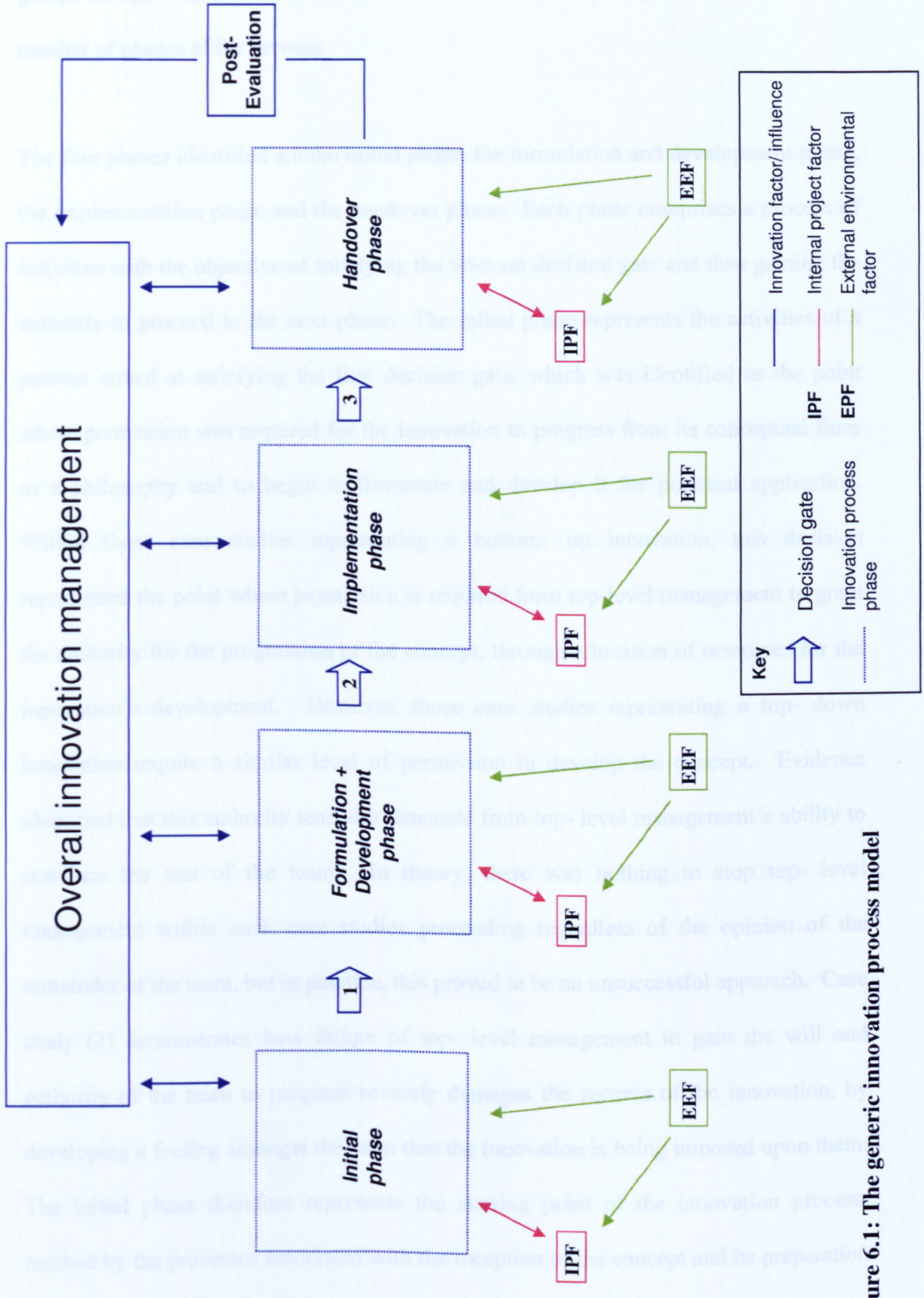


Figure 6.1: The generic innovation process model

groups of activities geared towards its satisfaction, thus forming and determining the number of phases of the process.

The four phases identified are the initial phase, the formulation and development phase, the implementation phase and the handover phase. Each phase comprises a process of activities with the objective of satisfying the relevant decision gate and thus gaining the authority to proceed to the next phase. The initial phase represents the activities of a process aimed at satisfying the first decision gate, which was identified as the point where permission was required for the innovation to progress from its conceptual form as a philosophy and to begin to formulate and develop it for practical application. Within those case studies representing a bottom- up innovation, this decision represented the point where permission is required from top-level management to grant the authority for the progression of the concept, through allocation of resources for the innovation's development. However, those case studies representing a top- down innovation require a similar level of permission to develop the concept. Evidence identified that this authority tended to emanate from top- level management's ability to convince the rest of the team. In theory, there was nothing to stop top- level management within such case studies proceeding regardless of the opinion of the remainder of the team, but in practice, this proved to be an unsuccessful approach. Case study (2) demonstrates how failure of top- level management to gain the will and authority of the team to progress severely damages the success of the innovation, by developing a feeling amongst the team that the innovation is being imposed upon them. The initial phase therefore represents the starting point of the innovation process, marked by the processes associated with the inception of the concept and its preparation for the decision to authorise its progression to the next phase. Failure to achieve the authority required resulted in practice in these processes being revisited until it is granted.

The second decision gate represents the point where authority is required to assess if the formulated and developed concept is ready for practical application and implementation. A good example of the implications of this in practice is supplied by the reed bed case study where both the project team and the top-level management had to be 100% satisfied of both the technical and financial viability in practice of the innovation. If satisfaction of both of these criteria fails, then evidence illustrated that activities of the formulation and development phase are revisited until satisfaction is achieved or the project is abandoned. Examples such as case study (3) demonstrate the need for top- level management to achieve 100% satisfaction that both the innovation was suitably developed for implementation, and that the project team were involved and engaged with the concept. The client placed considerable emphasis in providing the project team with access to participate in the activities of the phase. As a result, the entire team were able to understand the justification for the use of the innovation, through their involvement and ability to contribute to ensuring its suitability for implementation. This example illustrates that where care and attention is placed on these needs, progression was successfully achieved. Case study (2) provides evidence that although the final decision remains with top-level management, failure to achieve the authority of the team prior to implementation restricts significantly the potential for success. Within this example, top- level management failed to acknowledge the need to involve the project team in the activities of the phase, resulting in a team that failed to understand and accept the suitability of the concept for implementation. The formulation and development phase therefore represents the process of transferring the concept from a philosophy into a developed concept ready for implementation.

The final decision gate represents the point where a decision is reached regarding the completion of the implementation phase (marked either by the termination of its use or the physical completion of its implementation depending on the context), and the progression to the handover phase of the process. In case study (3), the decision is represented by the satisfaction of the team that the use of the concept is terminated in practice. In the example this coincided with the competition of the construction projects, however this need not be the case. This contrasts in nature with the grass roof case study, were the decision gate is marked by the satisfaction of the project team that the implementation has been physically completed. As with the other decision gates if authority to progress is not formally granted by the team, the activities of the implementation phase are revisited until satisfaction is achieved. Therefore, the phase involves the process of managing the implementation of the developed concept and represents the transformation into its practical function.

The final phase of the process is the handover phase. This represents the process where performance is evaluated and the requirements for the future of the innovation are considered (i.e. its maintenance and operation as a function, and lessons for its future consideration etc). The grass roof case study provides a good example where following the completion of implementation, responsibility for the roof transfers from the construction team to the clients housing management team. Within case study (3), this phase represented the process of evaluating the performance of the innovation and ensuring lessons for future use prior to the dispersal of the team from the project.

Within many of the case studies, this phase was largely unstructured and unplanned, however, it occurred as a response to the experience of the process. Those case studies that formally included such a phase from the outset, such as case study (3) and the grass roof case study, were able to maximise the learning process gained through this phase, in addition to planning aspects such as maintenance of the innovation (with particular reference to the grass roof). Examples such as case study (2), which failed to plan for such a phase within the process, found themselves using it as a response mechanism to events as opposed to an opportunity for learning.

The series of activities identified in each phase was observed during analysis to not exist in an identifiable generic order. This made the process of identification of an overall process difficult, as every case study appeared to follow a slightly different sequence of activities within each phase geared at satisfying the relevant decision gate. An example of this issue is provided when comparing the nature of the process of activities for the initial phase within case study (1) and the roof insulation case studies. Although the activities of the phase process were constant in their appearance at a high level, the nature and characteristics (attributes) of the case studies resulted in the sequence differing in accordance to need and requirements. This observation is significant, as it requires that the activities within each of the phases be viewed as occurring in an interactive and flexible manner with the order decided through need reflective of the context. Evidence from the case studies highlighted also the need for a fluid process as activities are revisited in order to achieve the satisfaction of the decision gates. An example of the fluid nature of the process is supplied within case study (3), where the project team were constantly revisited and consulted regarding the nature of the innovation during the initial phase of the process. Within this example, the satisfaction of the decision gate could not be successfully achieved without revisiting this activity within the phase.

Initially it was difficult to identify many of the activities in the analysis of the case studies within each of the phases. Closer examination of the case studies revealed that much of the difficulty related to the blurring and merging of activities within the individual phases. Examples of the differing manner that the activities merge or blur in their appearance within the individual phase processes can be highlighted as occurring in a differing manner when comparing case study (1) and the reed bed case study. When contrasting the phase process of the initial phase in each case study it was apparent that although the appearance of certain activities contrasted in the manner that they were merged, the difference was dependent on the form of the attributes and the context. However, within all the case studies despite the sequence, fluidity and fuzzy nature of the activities, for each phase to successfully progress through the satisfaction of the decision gates all of the activities observed require to be satisfied. The recognition of the fluidity and fuzzy nature of the activities within each phase allows a generic model to retain its need to be flexible to the context of each of the attributes.

The analysis observed that each phase is individually influenced by both external environmental factors and internal project factors. The nature of the influence of these factors differs from phase to phase and this reflects the differences in the objectives and processes of the individual phases. For example, changes to environmental regulations acted as a stimulus within projects such as the wind turbine, reed bed and the insulation material case studies. Within each of these, the process and individual phases enjoyed a facilitating culture throughout, as the team recognised the need for the innovation to be considered due to the need to accommodate the changed regulations. This contrasts heavily with experience in the passivent case study where the team culture acted as a barrier to the progression of the innovation process due to the optional nature of its status according to the regulations. Regulation changes within the reed bed case study represented an opportunity during the initial phase, but posed a threat during the implementation phase as they could result in the innovation being rendered obsolete.

The influence of the internal project environment was noted to influence the individual phases of the process. The impact of crisis within the project was noted within a number of case studies (particularly case study (1) and passivent) to exert significant pressures on the different phases of the innovation process. Crisis within a project affects all of the phases; however, the implications on each will depend on the objectives of the each of the phases. The analysis also observed the dynamics between the two sets of influencing factors, with evidence illustrating that although the internal project environment can have influence over the phase in question, it fails to have an influence over the nature of the external environment. By contrast, it is observed that the external environment has influence over both the internal project environment and the individual phase directly. Analysis illustrated that a facilitating regulatory stance by a government or favourable market conditions, impacts by facilitating both the internal project environment and the individual phase. This was demonstrated within the reed bed case study, where the internal project team (due to the business opportunity they viewed as achievable by exploring the environmental innovations), provided a supportive environment for managing the innovation process during all phases. This internal project environment was stimulated directly in response to the nature of the external environment. It would not have been possible for the project to take this approach without the facilitation of the external environment, as the internal project environment fails to influence the nature of the external environment.

The case studies revealed the existence of an overall management phase governing the entire process as interacting with each of the phases both individually and as a whole. This was observed as the management capability for achieving feedback and interaction with the process throughout its lifecycle. Case study (2) illustrates the ability of management within the process to monitor, gain feedback from and make adjustments across the process where necessary. Figure 6.1 illustrates the interaction between the individual phases and the overall innovation management, providing both influence and direction to each of the individual phases, in addition to providing feedback from the phases for evaluation. Arrows representing the directive, guiding, monitoring and feedback roles illustrate the interaction that is performed. Case study (2) implemented partnering as an innovation in two separate construction phases over the lifecycle of the process. Feedback from the implementation and handover phase in the first phase of the project was received by the overall innovation management and adjustments were made to the formulation and development phase for the projects second phase. Of particular concern was the lack of effective communication between team members within the first phase of the construction project, but the presence of the overall innovation management allowed for this element to be tackled prior to the implementation for the second phase. The overall innovation management is identified as overseeing the four phases of the innovation process by monitoring and providing both influence and feedback between each.

The case studies revealed a need to acknowledge within the model the interaction between the innovation process and that of the project process. The identification of the attribute of innovation type (i.e. whether it was system, process or component) within chapter 3 was based on the differing relationships between the innovation and the project processes. Analysis of the case studies within the research backed the identifications made in chapter 3, and observed that management requires to integrate the needs of both processes within the context of their relationship. The overall innovation management process identified in the model illustrates the management response to this interaction with the individual phases of the process. Each phase is influenced by internal project factors as illustrated in figure 6.1, and this influence is responded to by the management of each individual phase. However, there is a need to reflect the management interaction with the individual phases in response to the nature of the overall interaction between the project and innovation processes. A good example of this need is provided within the passivent case study where decisions made regarding the project process had a direct management implication on the nature of the formulation and development phase, to the extent that the innovation process was terminated. Whilst the phase was experiencing negative stress from internal project factors, such as problems associated with the integration of the innovation with the project design and its finances, the implications of such were to place stress on both the initial, and formulation and development phase. Whilst these were difficult factors for management of the individual phases to control, the overall innovation management process continued to facilitate the innovation. However, when the overall innovation management process ceased facilitating the innovation due to changes in the decision for its inclusion by the project process, this resulted in the termination of the innovation process. The following section will discuss the structural breakdown of the interaction between the overall innovation management process and the individual management control system within each phase

Following the completion of the four phases of the innovation process, it was noted that although the handover phase performs activities of post process evaluation, there was evidence that suggested that such activities also occur post innovation process (i.e. following the completion of the handover phase). There is a need to make a distinction between activities of evaluation and feedback within the handover phase and those occurring following this. Whilst the handover phase was recognised as a formal part of the innovation process prior to the dispersal of the project team, evidence suggested that evaluation of the performance of the innovation and its implications, continued post innovation process. Whilst this may occur in a formal manner, it is most likely to be represented by conversations between team members on an informal level. Within case study (3), this was represented on a formal level through the presence of several team members from this project being involved in another project that considered using the same innovation. Naturally, the team members evaluate their shared experiences from the previous project in an attempt to improve their management of the process within the new project. The reed bed case study represents an example of the post process evaluation occurring in an informal manner, where the head of the project team regularly discussed the innovation's performance with the designer due to their established friendship, sparked by a common interest in promoting the application of reed bed technology. The model had to represent this process of evolution, and its interaction with the overall innovation management process. As the post evaluation process does not represent one of the four phases, and occurs outwith the confines of the process itself, it requires to be represented as a feedback mechanism to the overall management phase following the hand over phase.

The following section of the chapter will provide a detailed breakdown of each of the phases, firstly outlining the structure of the process of each phase, and secondly providing a detailed outline of each. The overall innovation management phase will be detailed within the following chapter due to the significance of understanding the integration between the management of the innovation and the project processes.

6.3 Structural breakdown of the individual phases of the process

The previous section outlined each individual phase as the activities required to achieve the satisfaction of the decision gate that forms the boundaries of each phase. Figure 6.1 identified the overall innovation management of the individual phase as providing its direction, whilst ensuring that sufficient monitoring and feedback existed between the overall innovation management and the phase in order to achieve integration between the innovation and the project. This is illustrated as a two-way relationship ensuring that the management of the phase process aligns with the remainder of the process. The influence of both the internal project factors and the external environmental factors on each of the phases was identified and arrows indicated the relationship that this influence exerts with the individual phase. Figure 6.2 displays the overall innovation management, internal project factors, and the external environmental factors, and reveals the interaction of the elements of the individual phase. Analysis of the case studies identified that each of the phases shared a common structure of elements that contribute to the managing of the process. The nature and context of each element of the structure is specific to the requirements of the individual phases of the innovation

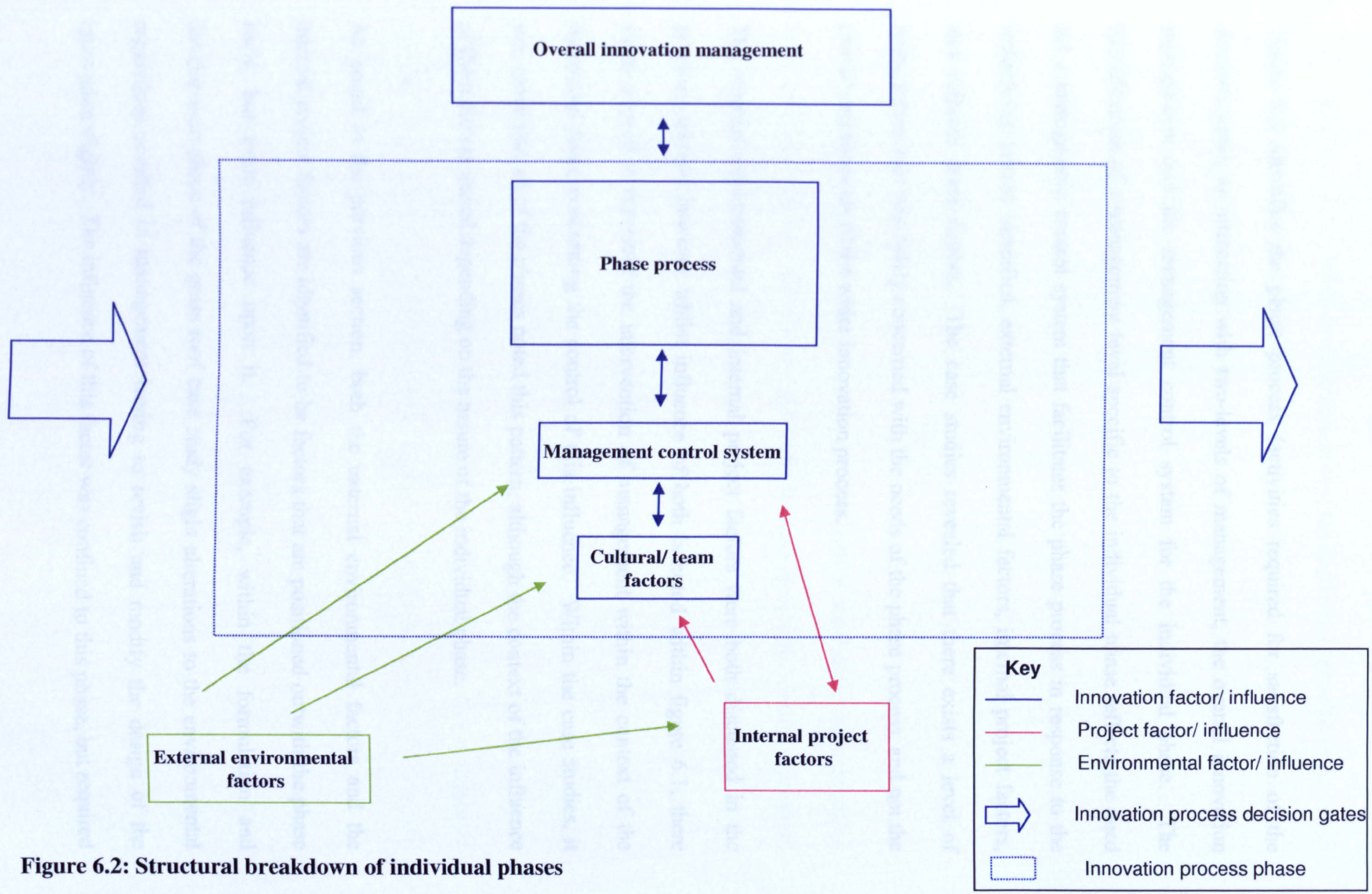


Figure 6.2: Structural breakdown of individual phases

process.

Figure 6.2 identifies the phase process (activities required for satisfaction of the decision gate), as interacting with two-levels of management, the overall innovation management and the management control system for the individual phase. The identification of a management level specific to the individual phase reflects the need for a management control system that facilitates the phase process in response to the influencing factors identified, external environmental factors, internal project factors, and cultural/ team factors. The case studies revealed that there exists a level of management that was solely concerned with the needs of the phase process, and not the overall requirements of the wider innovation process.

The external environmental and internal project factors were both discussed in the previous section, however whilst influence of both is noted within figure 6.1, there exists a need to represent the intervention of management within the context of the individual phase concerning the control of this influence. Within the case studies, it was noted that all of the phases noted this pattern, although the context of the influence of these factors varied depending on the nature of the individual phase.

As noted in the previous section, both the external environmental factors and the internal project factors are identified to be factors that are positioned outwith the phase itself, but exert influence upon it. For example, within the formulation and development phase of the grass roof case study slight alterations to the environmental regulations resulted in management having to revisit and modify the design of the innovation slightly. The influence of this factor was confined to this phase, but required management intervention to ensure that the influence was facilitated. Internal project factors were also identified to exert influence over the individual phase process, and to require management facilitation. Case study (2) provides a good example of this. The impact of project crisis was felt by each of the phases of the innovation process, and the influence on each of the phases was noted to differ, reflecting its nature and objective. Within the formulation and development phase the influence of a crisis in the project resulted in facilitation being required to ensure that the innovation was not abandoned due to difficult conditions. Within the implementation phase similar pressures required management support for the concept to ensure that the team did not move away from the use of the innovation in favour of another more traditional method. This was attempted by the use of workshops and activities aimed at improving communication lines within the team. Case study (1) and (2) were both unsuccessful overall in providing sufficient levels of management control during the individual phases of the innovation process, and as a consequence both external environmental and internal project factors were allowed to negatively affect the phase process of the individual phases continually. This was in contrast to case study (3), while experiencing similar problems, placed considerable effort on the management facilitation of these factors, in order that the phase process for each phase of the innovation process had a chance of success.

During the investigation of these factors it was noted that a third factor was identifiable as influencing the phase process, and requiring management facilitation and control, i.e. cultural/ team factors. These factors are distinct from the internal project factors, as the analysis identified that the cultural mindset of the team towards the innovation during specific individual phases significantly affected their interaction with the phase process.

Although these factors are often related to the external environmental factors and the internal project factors, they are not necessarily dependent, and require to be displayed as internal within the individual phase. For example, within the grass roof case study the team displayed a positive mindset within each phase towards the innovation and the nature of the phase process. This was influenced in this case by the nature of both the external environmental factors and internal project factors; however, this need not always be the case. Within case study (2) for example, both the external environmental and internal project factors were identified as being facilitating towards the innovation and the phase process, however the cultural mindset of the team towards it was not. There is a need for the management control system to facilitate the influence of the cultural/ team factors to ensure that they aid as opposed to hinder the phase process. Within this example, the team felt that although the innovation was seen as the way forward for the industry generally, they were not provided with sufficient option over its use and therefore remained sceptical throughout. Case study (2) failed to overcome this problem due the lack of consideration of the cultural/ team factors during the management of the formulation and development phase.

The arrows in figure 6.2 demonstrate the relationship between the factors of influence, highlighting the need for constant feedback between the phase process and the management control system, in order that changes and variations are accounted for. The remainder of this section will provide a detailed breakdown of each of the individual phases, illustrating the common structure, and the contextual nature of each element relating to the nature of the phase. Outlined within the discussion will be the three decision gates that punctuate the process, and provide the function for each of the phases.

6.3.1 Detailing the phase models

Figure 6.3 illustrates the detailed structure of the initial phase, identifying the key activities (phase process and management control system) and influencing factors (internal project, external environmental and cultural/ team) observed within the case studies. The structure illustrated within this figure is constant for all of phases and with that identified in figure 6.2. The detailed list provided within each of the element boxes, does not represent a hierarchy of significance, as analysis illustrated that although the appearance of each was generically present within each case study, the nature and order of significance of their appearance varied depending on the individual context and attributes. Analysis revealed that despite the often differing order, blurred, fuzzy and fluid nature of the activities and influencing factors, a generic set existed across this phase within all of the case studies. This chapter will concentrate on the generic aspects of the process, and will present the influence of the innovation and project attributes on management of the process within chapter 10 where an overall assessment is conducted.

A discussion regarding the interaction of the overall innovation management with the innovation process is outlined in the following chapter. It is necessary to understand at this point that whilst the overall innovation management varies depending on the type of innovation considered, the individual phases and decision gates exist as a generic process, applicable to all the attributes outlined in chapter 3.

During the consideration of the individual phases of the innovation process, it is necessary to observe that reference to the activities and influencing factors are discussed in the context of the management of the innovation process and not the project process. An example can be found in the identification of the significance of leadership and management support for the success of the process. There is a need to avoid confusion when referring to these terms with the leadership or management of the project process (although in the case of process innovations, they are interdependent).

Prior to discussing the individual phases of the process, it is necessary to observe the presence of an individual who aids the progress of the innovation process through their participation in both the innovation and project teams. The idea champion is a role that provides the innovation process with the necessary leadership and support throughout its integration with the project. As a member of both team's this individual was observed to provide the guidance and influence required to aid the progression of the innovation process through the satisfaction of each of the decision gates. The idea champion, although not always the individual responsible for managing the innovation process, through their shared role within both the project and the innovation processes is able to influence other members of the project team to facilitate the process. Evidence from the case studies observed that it was not necessary for the idea champion to be involved in the generation of the idea, but to be willing to support and lead its progression with the rest of the project team during its interaction within the project.

The role of the champion was observed to evolve over the course of the process to reflect the nature of each of the phases. As a consequence, the role developed in many case studies from focusing on the promotion and persuasion in the earlier phases of the process, and shifts towards one of representing the progress and delivery of the innovation in a practical sense within the project in the later phases. Due to the contrasting skills required to perform these roles it was observed in many case studies that the individuals involved may change.

The nature of the idea champion's role within the project team was observed to differ, depending on the nature of the relationship between the innovation and the project processes. Within the process innovation case studies, the idea champion was observed to be the project manager due to the interrelated nature of the processes. This contrasts with both the system and component innovation case studies. The system innovation case studies illustrated the idea champion as a member of the client body, who wanted to see partnering introduced into each of their projects, and thus provided an influence on the project team that was top- down in approach. By contrast the role within the component case studies was observed to be occupied by an individual who was merely a member of the project team, such as an architect, and therefore represented a bottom-up approach. The relationship between the idea champion and the project, reflects the nature of the interaction between the innovation and the project processes, an aspect that will be explored in chapter 7.

- **Initial phase**

The first decision gate of the process represented the point where permission was required for the innovation to progress from its conceptual form as a philosophy to begin to formulate and develop it for practical application. The initial phase of the innovation process represents the process of achieving the satisfaction of the decision gate. Figure 6.3 illustrates the structure of the initial phase, highlighting that the phase process represents the activities required to achieve the satisfaction of the first decision gate. Analysis revealed that these activities can be divided into two groups, 1) those

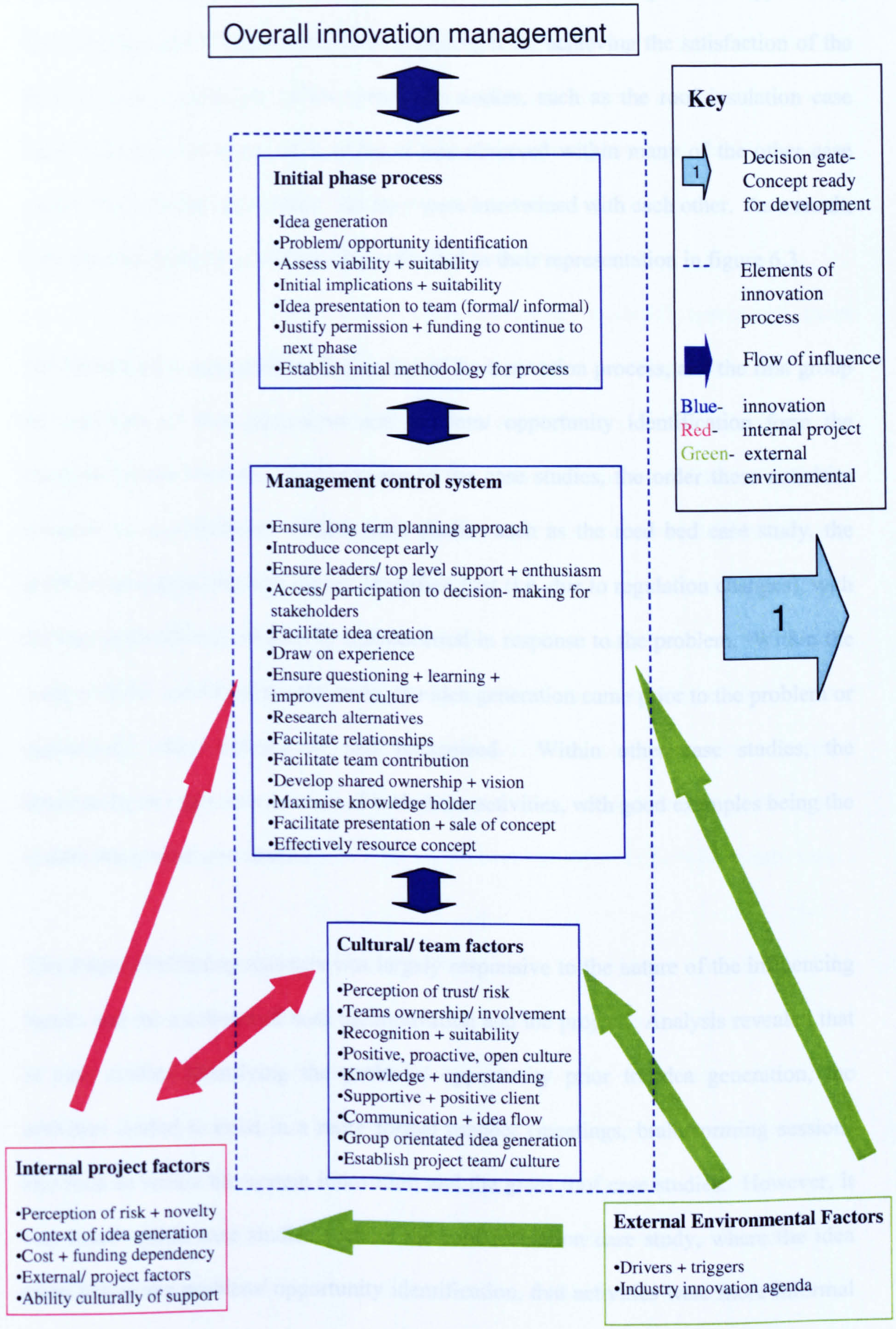


Figure 6.3: Initial phase of innovation process

relating to the inception of the concept i.e. idea generation and problem/ opportunity identification, and 2) those relating to preparing it for achieving the satisfaction of the decision gate. Although within some case studies, such as the roof insulation case study, the two sets appeared in order, it was observed within many of the other case studies (i.e. reed bed case study) that they were intertwined with each other. As a result, they are not displayed as a hierarchy or divided in their representation in figure 6.3.

The initial phase represents the beginning of the innovation process, and the first group the activities of idea generation and problem/ opportunity identification form the inception of the concept. Within many of the case studies, the order these activities occurred in was different. Within case studies such as the reed bed case study, the problem or opportunity was clearly identified first (i.e. due to regulation changes), with the idea generation as an activity that occurred in response to the problem. Within the context of the wind turbine case study, the idea generation came prior to the problem or opportunity being investigated and recognised. Within other case studies, the innovations emerged as a mixture of both these activities, with good examples being the system innovation case studies.

This range of differing manners was largely responsive to the nature of the influencing factors and the attributes of both the innovation and the project. Analysis revealed that in case studies identifying the problem/ opportunity prior to idea generation, the activities tended to exist in a more formal manner (meetings, brainstorming sessions etc) such as within the system innovation and the grass roof case studies. However, it was noted within case studies such as the roof insulation case study, where the idea came before the problem/ opportunity identification, that activities were more informal and unstructured. Where the activities were intertwined, there was noted to be a mixture of informal/ unstructured and formal/ structured. Closer analysis revealed that in most cases a mixture was observed, with greater significance being aligned to one approach depending on the nature of the case studies. The system case studies provided good examples of the use of both styles.

The second group of activities identified within the analysis represented those connected with achieving permission at the decision gate for the continuation of the process and the provision of resources for its development. These activities were observed as providing the decision makers with the evidence and basis required to accept the innovation concept. Analysis revealed that these activities could be split into two sub- sets, 1) assessments relating to the suitability, viability and the initial implications of the concept in practice, and 2) those activities relating to the presentation of the idea to the team and ensuring that a plan is established for an initial methodology for the process. Although the presence of an idea champion was observed to not be necessary within the context of the generation of the idea, there emerged a clear benefit from the effective leadership of such an individual in both these sub- sets.

The nature and appearance of both these sub- groups of activities varied because of the context of each individual case study, however a particular distinction was noted in relation to the flow of the innovation within a project team, i.e. whether it was top- down or bottom- up by nature. For top- down innovations, such as the system innovation case studies, these activities were adopted by top- level management to convince and persuade the remainder of the team of the need to progress the concept. In the case of bottom- up innovations, such as the wind turbine and roof insulation case studies, these activities were adopted by the remainder of the team with the objective of convincing and persuading top- level management of the need for progression. The idea champion's position within the project reflects this flow, as for top- down innovations they will be a member of the project team in a leadership role, and for a bottom- up innovations they will merely be a member.

Analysis revealed that the appearance or approach of these activities varied in nature depending on the attributes and influencing factors of the case study. The wind turbine case study illustrated an example of a structured and formal approach of these activities with meetings at various levels within the team hierarchy and the adoption of a formal methodology to assessing the viability and suitability of the concept. On the other hand, the roof insulation case study illustrated an informal process where assessments and persuasion took place in unstructured discussions between team members. However, a mixed approach was generally noted, with structural approaches such as the use of meetings, workshops and established methodologies for assessment, and unstructured approaches relying on the informal discussions between team members. This mix was noted to occur regardless of whether the innovation was top- down or bottom- up in nature. The selection of the appropriate approach for use was illustrated to be contextual to the form of the attributes and influencing factors of the case study.

The analysis revealed that in order to satisfy the objectives of the phase, a management control system is required to facilitate the phase process against the influence of the three identified groups of influencing factors. Figure 6.3 outlines the interrelating nature of these factors, displaying the individual factors observed within the analysis. As with the activities of the phase process, the significance of the individual factors of influence was noted to vary from case to case, resulting in the existence of no established hierarchy. In addition, within many of the case studies the factors were noted to be blurred and fuzzy in nature. This reflects the complex influence of the environment to which the phase process exists. Analysis identified that the management control system reflected this complexity through the fluid, blurred and fuzzy appearance of the activities identified within the figure. The analysis observed that the significance and nature of these activities are dependent on the context of the influencing factors and the attributes of the case study. However, although the significance and nature of the appearance of the activities varies from case to case, there remains a generic requirement for their consideration within any innovation process regardless of the context. The remainder of this discussion highlights two system innovation case studies, both considering the use of the same innovation (i.e. partnering) and experiencing similar influencing factors, but illustrating differing success levels due to a contrasting approach to management control adopted within the initial phase. Within both these examples the idea champion was observed as the client body and therefore represented a top- level management approach governing the project team.

Case study (3) demonstrated a management control system that successfully interacted with and facilitated the influencing factors during this phase. This case study showed a management team who recognised the importance of managing and controlling the innovation process throughout. With relation to the initial phase, the external environment provided a positive and facilitating influence for considering this innovation for development. Partnering formed part of the government's agenda for the future of the industry, and as a concept is being driven hard within the industry and government funding agencies. Despite this, top- level management needed to consider the perception of risk that was held by many within the project team due to the novelty and unfamiliarity that this presented to their own role within the project. The contractor, for example, voiced concern over the potential implications regarding the cost of the concepts use in practice. Concern also existed that the concept was being forced on the team by the suggestion by the funding agency for its use. The temporary nature of the project team also brought doubts regarding the ability of the team to work together in a manner that culturally supports the consideration and use of innovations. The contrast between a positive external environment and a sceptical internal project environment in addition to directly influencing the phase process, influenced the nature of the cultural/ team factors influencing the phase process. The cultural atmosphere of the project team towards the innovation and the activities of the phase process was supportive of its consideration within the activities, despite the concerns described above. The client attempted, during the selection process for the project team, to assemble a team that culturally were open and proactive towards the consideration of innovation. Team members were sought who were familiar to them and could be relied upon for a good communication flow. Despite the positives, there remained a need within the team to be convinced regarding the potential risks and implications of using the innovation in practice.

The management control system, due to the nature of these influencing factors, needed to facilitate the phase process against two potential problems. The first relates to the potential that the positive external environment influencing the phase process, can in some cases lead to a concept progressing without serious consideration given its practical suitability for the particular project. Within this case study emphasis was placed on ensuring that sufficient experience was drawn upon from outside the project, in order that the team could maximise their knowledge base regarding the practical implications of using the innovation. Evidence of this was provided by trips organised by the client for the key members of the team to visit other projects currently using the concept. Emphasis was also placed on the need to ensure that the innovation was contrasted with alternatives to ensure that the activities of assessment would compare and select the most appropriate method for the needs of the project. The management control system was successful in facilitating this potential problem through a range of formal (workshops and meetings) and informal (plenty of one-on-one discussions) approaches.

The second potential problem for the activities of the phase process related to the scepticism of the team towards the implications of its use on their own role within the project. The activities discussed above obviously aid in the facilitation of this problem, allowing for the knowledge base of the team to be maximised during the activities of the phase process. Within this example, management acknowledged the need to involve the team as early as possible, and if possible during the activities of idea generation and problem/ opportunity identification. The levels of ownership that a team gains from a close level of involvement with the activities of the phase process was shown to facilitate the knowledge base of the team, thus lowering the levels of scepticism towards the concept. Management found that by involving the team early in the process and making them part of the decision-making processes, reduced the need for top-level management to sell the concept. By making the team part of the activities of the phase process, management achieved the creation of a culture aimed at improvement and learning as opposed to one of resistance towards the concept.

The success of the management control system within case study (3) contrasts heavily with the experience of case study (2) and the failure within this example of management to acknowledge the need to facilitate the phase process against the impact of the influencing factors of the three groups. This contrast between the two case studies is even starker as they both involved the consideration of the same innovation (i.e. partnering) and experience similarities in their factors of influence. The same two potential problems observed within case (3) were observed as requiring management control and facilitation within case study (2). However, analysis revealed that within this case study little, if no attention, was placed on their facilitation, resulting in the concept being accepted at the decision gate without an effective assessment taking place regarding its suitability and practical implications. The client representative within the project team, although leading the project and the activities of the phase process believed that the top- level management within his organisation had already concluded prior to this, that the concept was to be implemented regardless. He understood that they were encouraged by the facilitating external factors that the innovation would work in practice. As a result, due to the positive view encouraged by the top- level management, the conceptual assessments regarding its viability and suitability in practice were largely ignored. This resulted in the adoption of a concept that was not necessarily the best or most suitable for the project.

With relation to solving the problem of the team's scepticism of practical implications of the innovation's use, the lack of a thorough process of assessment, and the activities associated with persuading the team of the merits of the concept, failed to achieve facilitation. The management within this case study failed to acknowledge the benefits of achieving the involvement and ownership of the team in combating the affects of scepticism.

The contrast between the two examples highlights the need for achieving management control over the three groups of influencing factors in order that the activities of the initial phase are conducted effectively.

- **Formulation and development phase**

The satisfaction of the second decision gate of the process represents the point when the decision makers are satisfied of the concept's readiness for implementation. The case studies illustrated the formulation and development phase as the progression of the process through the allocation of project resources (time and financial), with the aim of formulating and developing the innovation from the philosophical concept to one that is ready for practical implementation. This phase represents the process of achieving the satisfaction of the second decision gate.

The need to convince the decision makers that the innovation has been developed sufficiently to enable it to be implemented, defines the nature of the activities of this phase. Figure 6.4 illustrates the set of activities within the phase, and although they appear in a varied manner within each case study, it was possible to divide them into two sets for the purpose of this discussion, 1) activities of assessment (feasibility, technical/ financial, and risk/ impact) and 2) activities of planning (planning/ development for implementation for practical application, technological, infrastructural, formulation of conditions for the project specifics, and assessment of its integration). In association with both of these sets were also identified two activities that are necessary

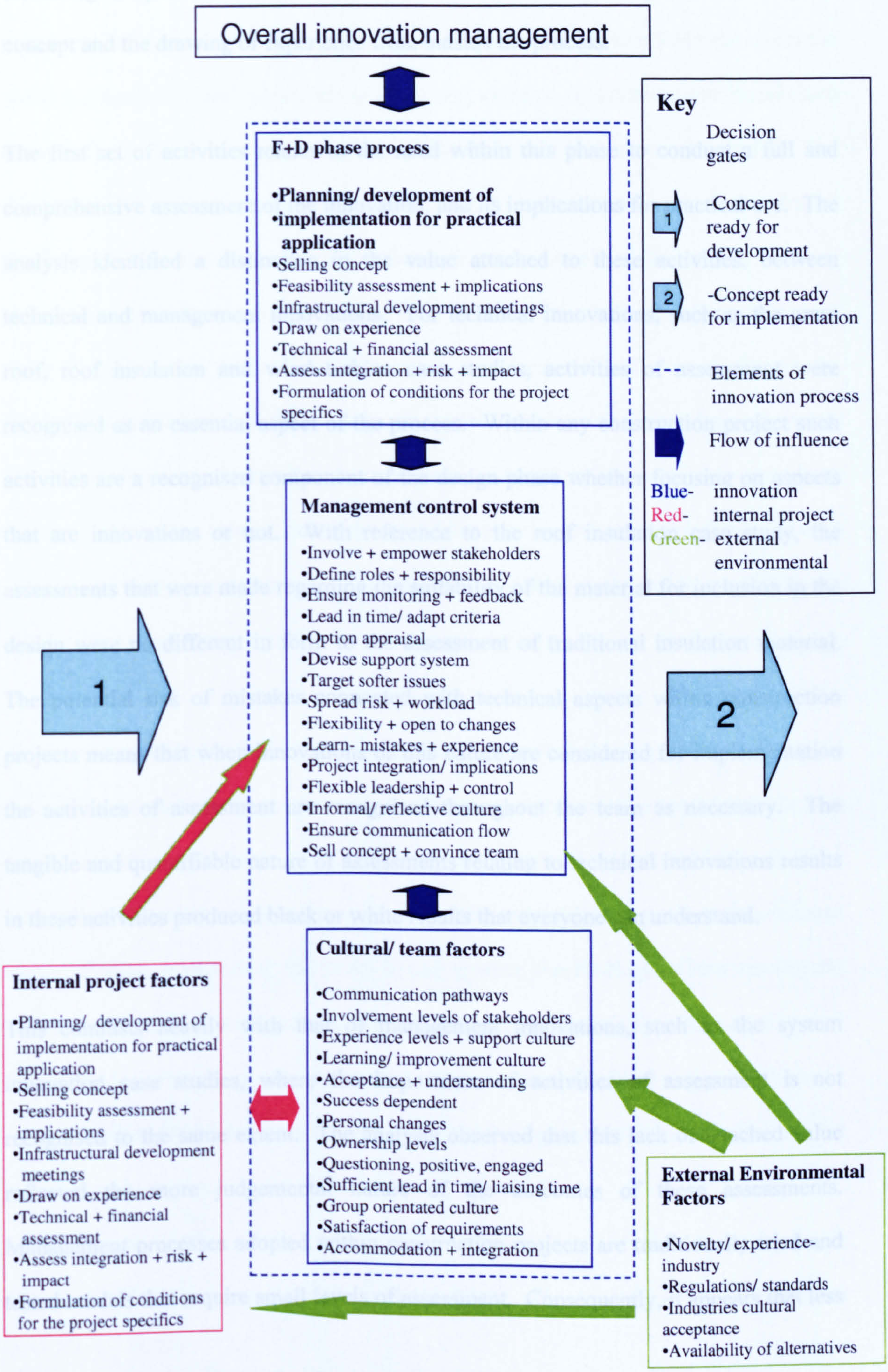


Figure 6.4: Formulation + development phase of innovation process

for aiding the process to achieve the satisfaction of the decision gate, i.e. selling the concept and the drawing of experience from outside the process.

The first set of activities relates to the need within this phase to conduct a full and comprehensive assessment of the innovation, and its implications for practical use. The analysis identified a distinction in the value attached to these activities, between technical and management innovations. For technical innovations, such as the grass roof, roof insulation and wind turbine case studies, activities of assessment were recognised as an essential aspect of the process. Within any construction project such activities are a recognised component of the design phase whether focusing on aspects that are innovations or not. With reference to the roof insulation case study, the assessments that were made regarding the suitability of the material for inclusion in the design were no different in form to the assessment of traditional insulation material. The potential risk of mistakes connected with technical aspects within construction projects means that when innovations of this nature are considered for implementation the activities of assessment are recognised throughout the team as necessary. The tangible and quantifiable nature of assessments relating to technical innovations results in these activities produced black or white results that everyone can understand.

This contrasts heavily with that of management innovations, such as the system innovation case studies, where the importance of activities of assessment is not recognised to the same extent. The analysis observed that this lack of attached value reflected the more judgemental nature of the outcomes of these assessments. Management processes adopted within construction projects are traditionally tried and tested models that require small levels of assessment. Consequently, it appears that less value and a difficulty in understanding how to interact with such an innovation for the purposes of assessment exists for many. The dangers of failing to effectively assess the viability, feasibility and potential of using the concept in practice, are highlighted through the contrast between case study (1) and (3) and that of case study (2). The management of both case studies (1) and (3) clearly demonstrated an understanding of the value of these activities within this phase. A good example of the benefits that they both gained from this is represented by the improvements and alterations that were made to the concept prior to implementation in order to tailor the innovation to the requirements of the project. Case study (2), due to the failure to acknowledge the value of such activities, implemented an innovation in practice that was unsuitable in its form for the needs of the project environment. Effective assessment would have allowed adjustments to be made, or even an informed decision to be made regarding the suitability of progressing with this form of the innovation.

The second set of activities identified were those related to planning and developing the innovation concept for its practical implementation. Assessment revealed that the two sets of activities operate in tandem to each other and are interdependent. A good example of the relationship between the two sets is highlighted by the grass roof case study. Evidence observed the need to incorporate the findings of the assessment activities (i.e. the implications noted on the overall project design) in the planning and development of the concept for the implementation phase. Evidence suggested the need for continual feedback between the two sets as changes in either bring implications for the other.

Analysis revealed that not only did an effectively planned and developed innovation concept enhance the potential for success during implementation, but was more likely to achieve permission to progress at the decision gate. A strong correlation existed between the case studies demonstrating a successful innovation process and those that effectively planned and developed the concept through these activities.

As with the first set of activities, a distinction was noted between the perception of value placed on the need for planning and developing the concept, depending on whether it was a technological or a management based innovation. The case studies illustrated that such activities came naturally when considering technological innovations. These activities were closely aligned in nature to traditional planning and development processes for any technological element of the project. The only contrast noted was the need to ensure that the facilitation of the knowledge base of the team was enhanced throughout the remainder of the innovation process. The outcome of the assessment activities regarding the technical and financial implications of the innovation are incorporated within these activities, and a planned concept tailored to the individual requirements of the project is developed. All of the technical based innovations demonstrate the recognised value of these activities within this phase, and although some are not successful in other aspects of the innovation process, they all benefited from an understandable and well developed concept.

In contrast case studies illustrating management based innovations were identified to place less value on the need for planning and developing the innovation concept. The reasoning behind this is shared by the explanation provided for the activities of assessment, as they are not as strongly aligned with traditional activities of the project process. The need to plan and develop the innovation concept to a suitable level was illustrated particularly within case study (2). Many within this example felt that the development of the concept in the initial phase was sufficient. The consequences of this failure resulted in the implementation of a concept that failed to establish an adequate level of knowledge relating to its implications within the project team, a planned management support system during its implementation, and the implementation of a concept that was not tailored to the requirements of the project. Case studies (1) and (3) placed emphasis on these activities, and to a certain extent avoided the problems noted in case study (2). However, both demonstrated unfamiliarity with the nature of these activities and required facilitation from the management control system.

As with the initial phase, these two sets of activities were noted to be intertwined, fluid, and fuzzy reflecting the form of attributes of both the innovation and the project. Analysis also noted the continual revisiting of individual activities in order to achieve satisfaction of the decision gate, illustrated by case studies such as the reed bed and wind turbine case studies. Within both of these examples, the decision makers asked for clarification or the development of a particular element of the concept in order for the permission to implement to be granted. Two additional activities were identified as appearing in a fluid nature within the process, that of drawing on the experience of others and selling the concept. Both of these activities were observed as playing a part in both of the identified sets of activities, and individually as aiding the presentation of the developed concept to the decision makers.

The phase process was identified to be exposed to three groups of influencing factors operating in a complex and interdependent manner, requiring both control and facilitation through a management control system. Figure 6.4 displays the activities of the management control system identified within the analysis as requiring consideration when facilitating the phase process. The significance and nature of the appearance of these activities reflects the contextual nature of the factors of influence on the phase process within each case. The remainder of this discussion focuses on the interactive nature of the management control system during this phase within the grass roof case study.

The phase process for the grass roof case study, was influenced by a combination of factors that were generally positive by nature. The external environmental factors were observed to be in the main positive and supporting towards the innovation's assessment and planning/ development. The team recognised that the use of such an innovation tied in with the direction of the government's sustainability agenda. Recognition of the future direction of roofing regulations, and the availability of funding, helped to facilitate the atmosphere surrounding these activities. However, this was countered by internal project factors, such as the doubts existing over the perceived risk that the innovation presents to the wider project. The contractors and Q.S., for example, were concerned over the potential implications on the cost of the project of the use of the innovation. The remainder of the team demonstrated a positive outlook towards considering innovations within the project environment.

The cultural team factors influencing the phase process exist as a mix of positive and negative factors requiring facilitation. The positive backdrop of the supporting external environment provided the level of interest and engagement from most of the team members to allow the assessment activities to be conducted in an open and fair manner.

The concerns of the contractor and the Q.S. relating to the potential risks and cost of implementation sparked a need to justify of the concept's suitability. Within other case studies (i.e. case study (2)), such concerns may have had negative consequences on the phase process. However, the combination between the positive external project factors and the sceptical internal project factors within this example provided the focus for a thorough assessment and production of a detailed plan of the innovation's implications.

The project team enjoyed an established relationship with each other, providing a good basis for communication pathways and levels of involvement relating to the activities of this phase. Many of the team members had experience of working with each other in other construction projects that involved the consideration of other innovations. Although the project team was multi- party and temporary in its form, the established nature of many of the relationships, both personal and professional, greatly enhanced the levels of trust and group interaction within the team. This level of familiarity, with not only each other but also of working with each other on other innovations processes, provides an open and questioning culture where seeking improvement is seen as the goal.

For this case study the role of the management control system is to maximise the facilitating benefits of both the external environment, and the beneficial cultural environment of the project team. Many of the activities identified within figure 6.4 were already established naturally within the team, and therefore the role of the management control system was to maintain and develop them further. Activities such as retaining the good communication flow between team members through both formal and informal pathways, was illustrated as enhancing the interaction levels of the team with this phase. Formal meetings were incorporated within the activities of the phase process, in addition to the encouragement of informal discussions between the team members. Management recognised the benefits of using the positive cultural relations within the team for the innovation process, and set out to devolve responsibility for the concept throughout the team. Roles and responsibilities were defined clearly within the team, with the aim of ensuring that the team members understood their role within the phase process. By achieving this, the team demonstrated qualities of empowerment and involvement throughout the phase. Within this case study the idea champions were observed to be the client and the architect, and they assumed responsibility for facilitating these aspects within the remainder of the project team.

The client promoted a learning culture during the phase process aimed at promoting the recognition of the value of innovation for developing and gaining experience. This reduced the fear of risk within the team and allowed for a more informal and reflective culture to be developed. The benefits of these facilitating activities provided a basis during the phase for overcoming any barriers that scepticism emerging from certain team members towards the concept may have presented. Within this environment, such scepticism can exist, but its affect will be positive as it fuels the questioning nature of the phase process. Within this example, the management control system provided the incentive for those who were sceptical of the innovation to enhance their knowledge base relating to the innovation. Failure to harness these concerns in an effective manner can potentially damage the phase process due to the negativity that it can bring.

This case study demonstrates that the phase process, even if influenced by a positive set of factors of influence, requires an interactive management control system capable of facilitating the activities of the phase process.

- **Implementation phase**

The final decision gate of the innovation process represents the point where a decision is reached regarding the completion of the implementation phase (marked either by the termination of its use or the physical completion of its implementation depending on the context), and the progression to the handover phase of the process. Analysis identified that this phase involves the process of managing the implementation of the developed concept emerging from the previous phase, and represents the process of its transformation into its practical function. Evaluation of the activities of the phase process revealed that for discussion they can be split into three sets; 1) activities relating to the structural planning and facilitation of the implementation process (an established methodology and program, sufficient provision of resources and control, and structural facilitation measures), 2) activities connected to the monitoring and feedback of the performance of the implementation process (gauge difficulty in practice, feedback and improvement and evaluation meetings, and monitoring standards and quality during implementation), and 3) activities associated with supporting the inclusion of all of the stakeholders within the process (integration of contractors and subcontractors, and catering for external stakeholders).

As noted within the previous phases, analysis revealed that these sets of activities existed in an interdependent manner, having no established hierarchy or order, and in many cases being fuzzy and fluid. Despite this, it was possible to identify a generic requirement for the three sets of activities to be considered within this phase. The occurrence of the activities is determined by the form of the attributes defining the nature of both the innovation and the project, therefore varying from case to case. The revisiting of activities was also determined to be a feature of this phase, until satisfaction is achieved at the decision gate. As a consequence, the activities displayed in figure 6.5 within this phase are shown in an unstructured manner.

It was observed that the role of the idea champion adapted during this phase, to assume the responsibility within the project for ensuring that the innovation was delivered into the project in the manner intended. This role was perhaps less about championing the innovation and its process to the rest of the project team, and more about ensuring its successful management during its integration with the project. It was observed within case studies such as the grass roof case study that the person assuming this role may alter from the previous phases, due to the differing demands it presents.

The first set of activities relate to the need within the phase to effectively plan the structure of the implementation process and its facilitation. Analysis revealed that much of the preliminary planning of the structure of the implementation process was established in the previous phase. As a result, within technologically based case studies such as the grass roof and reed bed case studies, these activities represented a refinement exercise where plans are adjusted in relation to the practical realities of implementation. However, analysis showed that for the management based innovations this required considerably more attention in practice than merely refinement, due to the lack of familiarity and understanding of the implications of implementing such concepts into the project environment.

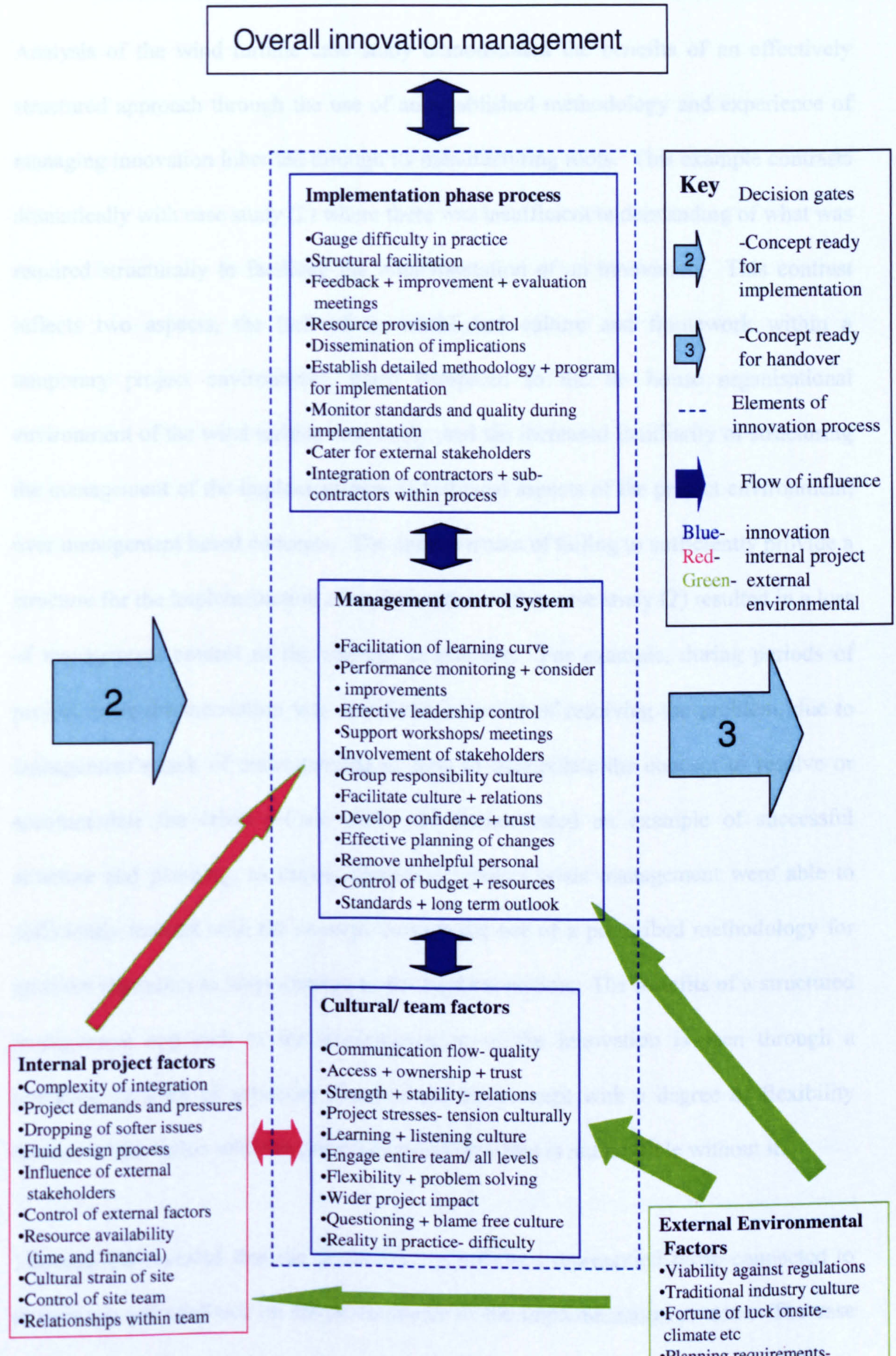


Figure 6.5: Implementation phase of innovation process

Analysis of the wind turbine case study demonstrated the benefits of an effectively structured approach through the use of an established methodology and experience of managing innovation inherited through its manufacturing roots. This example contrasts dramatically with case study (2) where there was insufficient understanding of what was required structurally to facilitate the implementation of an innovation. This contrast reflects two aspects, the lack of an established culture and framework within a temporary project environment, when compared to the in- house organisational environment of the wind turbine case study, and the increased familiarity of structuring the management of the implementation of technical aspects of the project environment, over management based concepts. The consequences of failing to sufficiently provide a structure for the implementation of an innovation within case study (2) resulted in a loss of management control of the concept in practice. For example, during periods of project crisis the innovation was sacrificed in favour of resolving the problem, due to management's lack of understanding of how to manipulate the concept to resolve or accommodate the crisis. Case study (3) demonstrated an example of successful structure and planning, as during periods of project crisis management were able to sufficiently interact with the concept through the use of a prescribed methodology for problem resolution to avert damage to the implementation. The benefits of a structured management approach to the implementation of the innovation is seen through a provision of a set of activities that provide the concept with a degree of flexibility during its interaction with the project environment, that is not possible without it.

The analysis revealed that the second set of activities represented those connected to monitoring and feedback on the performance of the implementation process. The case studies contrasted heavily in relation to the use of these activities, however a strong correlation was observed between the presence and use of activities such as these and successful implementation. Case studies enjoying a successful implementation demonstrated a management that interacts with the innovation constantly to assess its performance, suitability and future requirements. Examples of such activities were observed within the component innovation case studies where emphasis was placed on ensuring that the standards and quality of the wider project were replicated and maintained through the implementation. The assessment of the quality of the integration of the innovation was noted within all of the component innovations, and although this was evident to a certain extent within both the system and process innovation case studies, they were not of such significance.

Activities of monitoring provide management with the information required to make adjustments to the implementation of the innovation through the process of feedback. All of the case studies demonstrated the activity of feedback within this phase, some displaying a formal approach and others informal. Case studies such as case study (3) and the wind turbine case study demonstrated a formal approach to achieving feedback following the monitoring of the performance of the implementation. These activities took the form of meetings where evaluation and improvements are considered. Within case studies such as the reed bed case study these activities were noted to be informal in nature and achieved through one on one discussions between team members. The nature of the approach taken for these activities depends largely on the cultural context of the project team. Also in relation to these activities was the need for the experiences and implications of the implementation process to be disseminated, throughout the project team, within the relevant organisations, and potentially to the external environment. This provides the opportunity for the management team to learn from the opinion of others whilst the implementation process is ongoing. The case studies associated with the Construction Excellence Demonstration Projects highlight examples of this, with the benefits of allowing external bodies to comment on the process.

The third set of activities revealed the value and need of facilitating the involvement of the wider stakeholders of the project throughout the implementation phase. Analysis illustrated examples such as case study (3), where the inclusion of the wider stakeholders of the project team aided the implementation of the process. Top- level management placed considerable emphasis on expanding the knowledge base of the team, and felt the inclusion of the wider stakeholders (i.e. representatives from the funding agency, tenant groups etc) would benefit the process through their potential contribution, and would help to reduce any barriers that they may cause through a lack of knowledge. Case study (1), on the other hand, although implementing a similar innovation, demonstrated an example of the failure to include the wider stakeholders within the process. This led to enhanced resistance towards it, due mainly to their lack of knowledge and unfamiliarity towards it.

The value of including the contractor and those at site level within activities of this phase was illustrated within many of the case studies, as inclusion of their expertise within the decision making process was shown to assist the implementation process. The roof insulation material case study demonstrated the benefits of gaining from the knowledge and expertise of those sub contractors responsible for fitting the material in the roofs. Improvements were made to the process of implementation and at site level cultural ownership of the process was achieved. The improvements that were suggested by the sub- contractors not only improved the process of implementing it, but also made the joiner's job easier. This contrasts heavily with case study (2) where failure to effectively include the site manager within the decision making process connected to the implementation, contributed in the failure to satisfactorily implement the concept to site level.

As with the previous phase, this one is exposed to the influence of three groups of factors that require a management control system in order to facilitate them. The influence of these factors exists in an interrelated and complex manner, with their nature being determined by the contextual nature of the case. This pattern is constant with those observed within the other phases. The remainder of this discussion highlights a comparison of two case studies that demonstrate contrasting experiences and approaches to managing these influencing factors. Case study (1) provides an example of the withdrawal of top- level management from this phase due to responsibility being devolved to the wider project team. Analysis highlighted the importance of management control within every phase of the innovation process, as successful facilitation was noted during the first two phases largely due the high level of attention provided by management to control the phase processes of each. Analysis revealed that the withdrawn in the implementation phase had a negative effect on the phase and resulted in serious problems during the implementation. This contrasts with case study (2), where management facilitation within any of the phases was only introduced to any significant level during this phase in response to the failure of the concept during its implementation within phase 1. The performance improvement noted within phase 2 followed the adoption of a management control system to guide the activities of the phase process, and illustrates the need for it and its contribution to the success of the innovation process.

The similarity between the type of innovation and the nature of the influencing factors within both these case studies, provides a good opportunity to highlight the need for and performance of the management control system. The external environment of both provides factors of influence relating largely to the traditional problems facing construction projects at site level. Planning requirements and regulations, and the fortunes on- site (i.e. climate) featured within both, placed pressure on the activities of the phase process. Internal project factors, although reflecting the context of the individual project, were closely aligned when a comparison was conducted. Within both, the pressures on the team to achieve a successful delivery of the project process, was seen as the principle priority. As a result, when the project ran into periods of crisis whether through cost or time related issues, the pressure to resolve the problems of the crisis within the project took president over any consideration of the innovation and its requirements. The pressure existed to divert resources and energy away from the innovation process, in order to resolve the current problems. Within both, periods of project crisis resulted in considerable pressure for the innovation to be disregarded for a traditional approach, thus reducing the level of risk involved. Within each case study, these pressures placed considerable strain on the cultural relationships and interactions of the team members. This occurred in relation firstly to the project, but also places pressure on the phase by potentially making it more difficult. The pressurised nature of the site environment of a construction project also aids cultural tensions surrounding activities of the implementation of an innovation, particularly with relation to an innovation such as this (i.e. partnering).

The pressures placed within these case studies on this phase from both the external environment and internal project environment help to form the context behind the cultural/ team factors of influence. Evidence within both of the case studies revealed the significant influence of factors such as poor communication levels within the team and the ability of a team to learn and improve the process of implementation. These factors were both observed to be key elements aiding the phase in case study (3), however they were observed to be lacking in both case study (1) and (2). The level of access, ownership and trust a team feels for an innovation clearly aids the innovation process generally, but particularly during the implementation phase. Within successful case studies, it was noted that these levels are established through the facilitation of the earlier phases of the process. However, case study (2) demonstrated a team that displayed none of these feelings towards the concept, to the extent that even during implementation the knowledge base of the implications of its use was very low. Case studies such as case study (3) illustrate the value of facilitating the culture of the team towards the innovation in the earlier phases of the process, and benefited from a team that questioned and aimed for improvement throughout the process within a blame free climate. Both case study (1) and (2) failed to display these factors as a result of the neglect of the facilitation of the team's culture in the earlier phases of the process.

The contrast in the application of the management control system between case study (1) and (2) however, demonstrates the value and need for its existence in relation to the success of the phase. The devolvement of the management of the implementation of the innovation to the lower levels of the project team in case study (1) effectively resulted in the abandonment of the management control system. Lower level management within this example were found to be influenced by the priorities of the project, and neglected the management needs of the innovation. A clear need for top- level management to be involved existed in order that the management of the phase could take a perspective that was not caught up in the practical difficulties of implementation. The benefits of this are seen within case study (3), where day to day project issues and pressures were not allowed to affect the wider picture of the implementation process of the innovation.

The pressures of the project environment, and the debilitating influence of periods of project crisis within case study (1), resulted in the derailment of the implementation of the innovation in favour of the adoption of a tried and tested traditional model. Those managing the phase process concluded that due to the unfamiliarity that exists relating to the innovation and its use within the project, the best course of action was to revert to a method that reduced the level of perceived risk, and aided the process of resolving the crisis. Evidence illustrated that team members did not have sufficient confidence and trust in the use of the innovation in practice. The absence of a management control system led to a failure by management to facilitate against this.

Case study (2) has been discussed within this chapter as a poor example of managing the innovation process. Certainly, within the first two phases of the process this is clearly the case, as the management failed effectively to adopt a management support system within each of the phases. Evidence of the significance of facilitating the activities of each of the phases, is demonstrated within the implementation of the innovation within phase 1. This case study was characterised by a poor knowledge base existing within the team, the lack of a feeling of involvement or ownership, and the lack of a management control system during implementation. The consequences during phase 1 of the construction project were for the implementation of the innovation to effectively cease to take place. Due to the poor knowledge base that existed throughout the team, people would claim that they were using the innovation in practice, when the reality they were adopting traditional methods. However, the pretence to use innovation stopped when the pressures of the project environment forced the project team to even abandon this and regard the concept as a failure.

To their credit, the top-level management of case study (2) recognised that the failure of the implementation of the innovation within phase 1 was rooted in the failure of the management of the innovation process as opposed to the failure of the concept. Management identified the need to adopt a management control system to protect the activities of the phase, and set out to achieve this during the implementation of the concept in phase 2. Three failures were identified by management as being the root of the failure of implementation during phase 1, 1) the poor communication pathways between team members relating to the innovation, 2) the lack of a feeling of ownership or involvement with the concept, and 3) the poor knowledge base of the team regarding the concept.

The poor knowledge base was highlighted by the open admission by many team members that they had never actually read any of the documentation regarding the innovation, but they claimed to be using it. During phase 2, management sought to address these problems, and felt that this would help to protect the innovation during implementation against the pressures of the project environment. Activities such as the facilitation of the learning curve and knowledge base within the team, through a series of support workshops, and increased use of specific team meetings geared towards the concept. This structured approach, allowed for the inclusion of the entire team in the process, and aided in improving both their feelings of ownership and the involvement they shared for the concept. A consequence of this was the development of a culture and structure to protect the concept from the pressures of the project environment. The level of improvement within phase 2 of case study (2), although not perfect, was noted to be considerable. The same team, exposed to the same influencing factors were able to achieve a successful implementation of the innovation within the project environment, by using a structured management control system.

The contrast between these case studies illustrates the importance of the management control system for the successful implementation of the innovation within the project environment. The complex nature of this environment, and the changing needs for integrating the innovation within the project, require monitoring and adjusting throughout. A team with a good knowledge base relating to the innovation, can aid the evolution of it as it is tailored to the needs and requirements of the project. This ability can only be achieved using a management control system to monitor, adjust, and support the nature of the activities of the phase process.

- **Handover phase**

The decision regarding the completion of the implementation phase marks the progression of the innovation process into the handover phase of the process. This phase represents the activities observed within the case studies in the post implementation period of the process. In some of the case studies a formal series of activities were observed which evaluated the performance of both the function of the innovation and the management of the innovation process, in addition to identifying the future requirements of the innovation (i.e. its maintenance and operation as a function, and lessons for its future consideration etc.). Examples such as case study (3) and the grass roof case study demonstrate the benefits that purposefully structuring these activities from the outset of the innovation process presents for learning and improving both the innovation and the innovation management process for the future. Within these case studies, the handover phase was recognised as a necessary phase of the innovation process from the outset.

Analysis revealed that the formal inclusion of this as a phase within the innovation process was absent within many cases. Despite the lack of recognition needed to formally structure such activities, evidence existed of their existence in some form within every case study. Case study (2) provides an example where the handover phase appeared in an unstructured manner, and emerged in response to the events and experiences of the implementation phase. Analysis revealed that the activities of the phase identified were the same as those observed in the grass roof case study. The difference between case studies (2) and the grass roof case study was that they emerged in an unstructured manner in response to need, as opposed to being structured and planned. Comparison of the two approaches revealed that a planned and structured handover phase significantly enhances the learning capabilities and long-term benefits gained from the overall innovation process. In case study (2), for example, employing these activities as a fire fighting exercise may be effective in resolving issues in the short term but fail to have long term benefits as they are not so concerned with the opportunity for reflection. Evidence suggested that the handover phase is most valuable within the innovation process when it is seen as a formal evaluation phase.

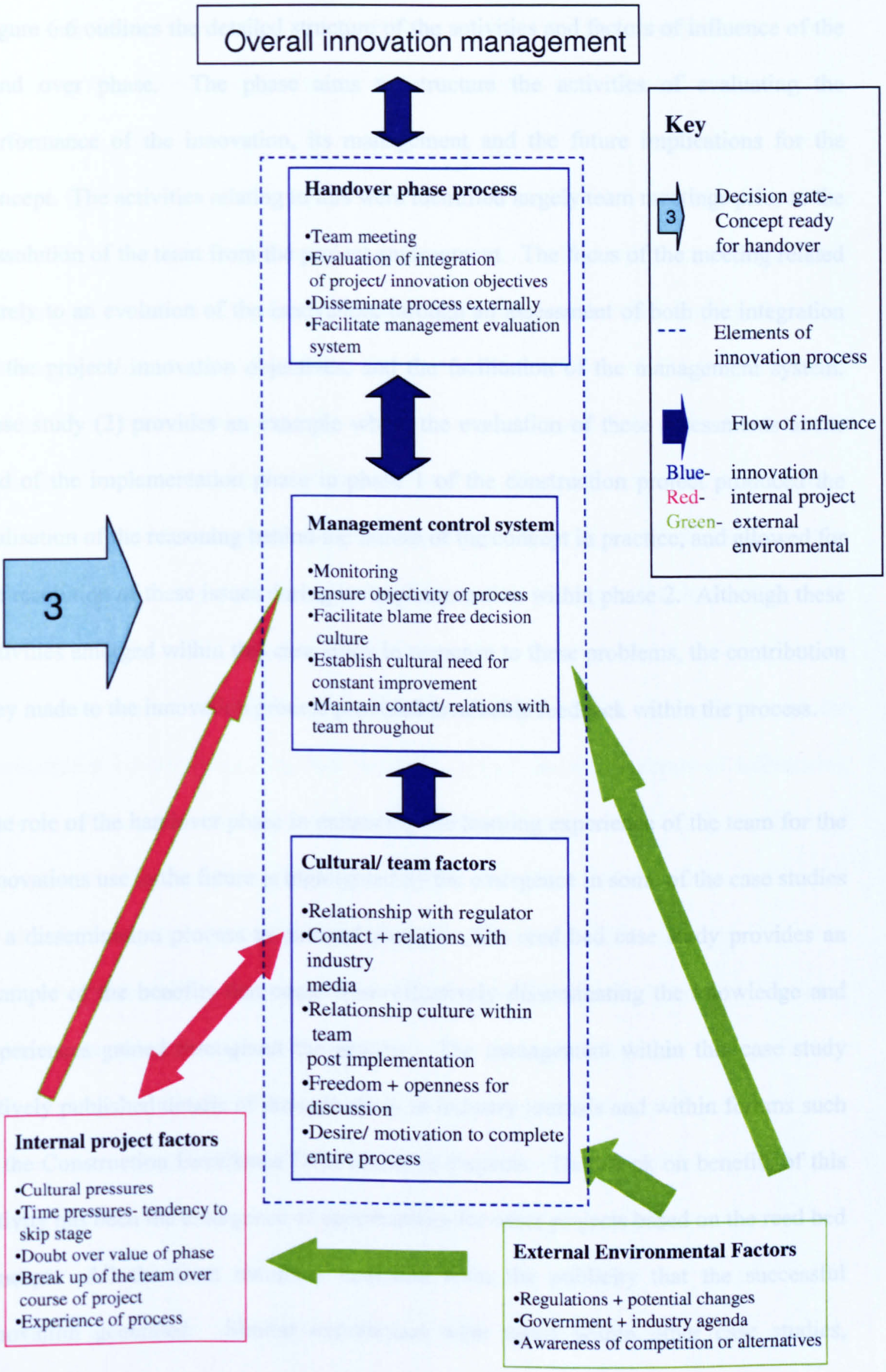


Figure 6.6: Hand over phase of innovation process

Figure 6.6 outlines the detailed structure of the activities and factors of influence of the hand over phase. The phase aims to structure the activities of evaluating the performance of the innovation, its management and the future implications for the concept. The activities relating to this were identified largely team meetings prior to the dissolution of the team from the project environment. The focus of the meeting related purely to an evolution of the innovation, through an assessment of both the integration of the project/ innovation objectives, and the facilitation of the management system. Case study (2) provides an example where the evaluation of these assessments at the end of the implementation phase in phase 1 of the construction project produced the realisation of the reasoning behind the failure of the concept in practice, and allowed for the resolution of these issues during its implementation within phase 2. Although these activities emerged within this case study in response to these problems, the contribution they made to the innovation process provided invaluable feedback within the process.

The role of the handover phase in enhancing the learning experience of the team for the innovations use in the future is highlighted by the emergence in some of the case studies of a dissemination process to external sources. The reed bed case study provides an example of the benefits that come from effectively disseminating the knowledge and experiences gained throughout the process. The management within this case study actively published details of the case study in industry journals and within forums such as the Construction Excellence Demonstration Projects. The knock on benefits of this activity has been the emergence of opportunities for other projects based on the reed bed concept. All the team members benefited from the publicity that the successful innovation generated. Similar experiences were noted within other case studies, however it was observed that this was tied to case studies that were successful. There exists a need to move beyond the fear of being seen within the industry to fail, as only by sharing the experiences of failure can lessons be learnt for the future.

As with the other phases of the process, the appearance of these activities follows no established hierarchy of significance or order, and can be fluid and fuzzy depending on the form of the attributes and context of the influencing factors. Unlike the other phases, no decision gate was observed to mark the completion of the activities of the phase. It was felt that these activities follow a natural lifespan that varies from case to case, with completion effectively being a matter of good practice as opposed to a requirement. Within many of the case studies the role of the idea champion was significant in providing the leadership necessary for the presence of such activities.

The achievement of an effective phase process is dependent on the facilitation of the management control system against the influence of the three groups of influencing factors (external environment, internal project and cultural/ team). Analysis observed the interrelated influence of the three groups, and identified that even within the handover phase, management facilitation of these complex influences requires to be responsive and interactive in order to achieve control. The remainder of this discussion will contrast the experience of managing two case studies, and highlight the significance of the management control system in achieving a successful phase process. Case study (1) and (3) provide examples of contrasting experiences within this phase, despite sharing similar attributes.

The value of providing a system for managing the control of the influencing factors during the handover phase, was not recognised within case study (1). The factors of influence from the external environment remained positive throughout the innovation process, due to the government's support and facilitation for the concept. Alternatives to the innovation remained limited, with the choice remaining between the uses of the innovation or reverting back to an established method of procurement. As a result, from the point of view of the external environment, the influence of the external factors provided an encouraging context to conduct the activities of the phase. Case study (3) shared the backdrop that these external environment influencing factors provide to the phase, however a contrast of the internal project and cultural/ team factors influencing the phase process within each case study highlights the value of the management control system in facilitation.

Analysis revealed that the project pressures that contributed to the failure of the innovation during the implementation phase in case study (1), had resulted in the development of a negative cultural relationship between team members. The tension that existed within the team over who was responsible for the failure of the innovation, in addition to other problems within the project environment, placed considerable pressure on the activities of the handover phase. Culturally, relations between team members were not strong enough to conduct an effective evaluation process, as tensions and a blame culture existed. Freedom and openness for discussion within such an environment would have proved difficult in these circumstances. Within the context of such an environment, the pressure to move on to the next job exists, and team members begin to doubt the value and time available for activities of evaluation. In addition, the desire of departed team members to rejoin the team during the handover phase to take part in these activities was a particular problem. These influencing factors provided a negative cultural atmosphere within which to conduct the activities of the phase, and required considerable facilitation in order to achieve anything meaningful out of the process. Within the context of case study (1), top-level management failed to see the need for a management control system, resulting in a process represented by a single team meeting that was poorly attended and dominated by a series of arguments, where team members passed the blame around the table.

Case study (3) has been used as an effective contrast with both case study (1) and (2) throughout this chapter. It has demonstrated the benefits of providing a planned and structured management control system for each of the phases of the process. Analysis of the internal project and cultural/ team factors influencing the activities of the handover phase process; illustrate the benefits of the effective facilitation of each of the previous phases. The contrast between the nature of the influencing factors within this phase of the process reflects largely the differences in the success of both the innovation in its integration within the project, and the cultural association that the individual team members enjoyed with the process of its management. The cultural problems identified within case study (1) were effectively a response to the failure of the innovation and its management process to integrate the innovation within the project environment. Pressures associated with the project, due to the lack of control in earlier phases, were allowed to damage the innovation process. Case study (3) although under similar project pressures during the process, due to the high level of management control, was able to facilitate the innovation, and reduce the cultural tension. As a result, case study (3) demonstrated a team culture where individuals engaged in the process, and viewed the handover phase process as a natural conclusion to the process. The experience of the innovation process for many of the team members within the process was something they valued, and aided the cultural relation within the team. The nature of the communication between team members throughout the process had produced a freedom and openness that was not apparent within case study (1). How much of this is simply down to the fact that case study (3) was a successful innovation process, or due to the effectiveness of the management control throughout the process is difficult to say. It is apparent from the analysis that they do coexist in successful case studies.

Case study (3), despite the favourable nature of the influencing factors, structured and planned the facilitation of the activities of the handover phase process. The need to monitor the nature of these factors throughout was retained, thus ensuring that management adjustments can be made when required. To achieve the level of contact and good relations experienced within the team, facilitation was required not only in this phase, but throughout the process. They recognised that only by communicating with individuals can the context of people's opinions be understood relating to the innovation. In order that the hand over phase enjoys a degree of objectivity and exists within a blame free environment, the nature of this culture requires to be facilitated by management. In this case study it was facilitated within the other phases of the process, however intervention was needed in the handover phase to aid relations in case study (1). Whether the situation in case study (1) had reached a point were facilitation of any kind would have not had the desired effect is unclear, however, an attempt may have helped salvage something meaningful from the phase.

The value of the handover phase needed to be recognised within some of the case studies, as not only of value for learning from successful innovation processes, but as a means of understanding and benefiting from bad experiences. Analysis of the handover phase also reveals the benefits of facilitating the culture of the team throughout the innovation process. Evidence illustrated the benefits that a positive culture within a team brings to the handover phase. However, a need also was identified for a management control system to facilitate the activities of the phase process during the hand over phase.

As discussed previously within this chapter, the handover phase represents the activities of evaluation within the innovation process, prior to the disbandment of the project team. Analysis revealed the need to separate the processes of evaluation that occurred as part of the structure of the innovation process (i.e. the hand over phase), and those that occurred post innovation process. This distinction allows for the development of an understanding that managing innovation, although existing as a four phase process within the project environment, continues in a limited form following the completion of these phases, as individuals continue to evaluate their experience of the innovation and its process.

6.4 Conclusion

This chapter outlined the generic structure of the innovation process emerging from the grounded theory analysis. Although generic in its nature, managing the innovation process in reality is fuzzy and complex by nature, requiring to be tailored to the individual context of the situation. The model demonstrates a best practice model, whereby following the principles outlined would significantly increase the chances of successful innovation management. It is possible for management to progress the innovation process without the satisfaction of the decision gates if the authority exists.

Case study (2) highlighted the dangers of implementing an innovation within the project environment that is unsuitable, not understood by the team and not facilitated. This situation would have been avoided if the requirements of the decision gates had been enforced and the individual phases revisited until the concept was ready to progress.

This chapter outlined in detail the role of the management control system within the individual phases of the process. A second level of management was identified within the process that interacted with the individual phases, considering the management requirements of the entire process in addition to its interaction with the project process. The following chapter assesses the role of the overall management phase of the process, highlighting the differing relationship between the innovation process and the project process for each of the types of innovation.

Chapter 7

7 Integrating innovation and project management processes

7.1 Introduction

This chapter aims to investigate the integration of the overall management of the innovation process identified within the research model with the wider management of the project process. The previous chapter outlined the model, illustrating the generic nature of both the process and its management requirements. However, although the processes and principles of the model were generic in nature, a different relationship was observed between the integration of the innovation process and the project process, depending on the type of the innovation. Analysis of these differing relationships suggests support for the definitions outlined in chapter 3 for each of the different innovation types. The nature of the integration of the innovation and the project processes is dynamic, requiring examination in order to achieve successful innovation management. This chapter will identify the project process model, highlighting its similarity with the innovation process model in terms of its structure and functions; present models illustrating the relationship between the project and the innovation process; and investigate the nature of the integration of the overall innovation and project management processes, by illustrating the structural relationship for the three innovation types. This will be supplemented by an investigation of the implications of these findings on the nature of the individual phases of the process.

7.2 The generic project management process

In order to understand the integration of innovation and project processes it is necessary to identify the structure and nature of the project process. The aim of this research is not to provide a model for managing the project process within construction, as many such already exist. The model outlined in figure 7.1 represents an adaptation of established models such as Kerzner (2003), and is matched by the observations from the grounded theory analysis. Phased models are an established method for displaying the process of project management within both general and construction management literature. Although the number of phases within such models can vary depending on the focus of the research, a four-phased model operating under the same structural principles as the innovation process model outlined in figure 6.1, was observed to represent the project process adequately for the purposes of this research. Although the phased structure of the two models is similar in form, the nature of the functions of the individual phases differs depending on their context. The four phases of the construction project process were identified to exist as inception, design, implementation/ construction and handover phases, followed by a post evaluation phase providing feedback to the overall project management. As with the research model, the boundaries of each individual phase are marked by a decision gate, which determines its function.

Analysis revealed that, within each of the phases, the process of activities existed in a flexible and fluid manner, similar to that of the innovation process model. Although not displayed within the model, analysis of the system case studies revealed that the use of partnering as a procurement route for these projects resulted in the integration of the

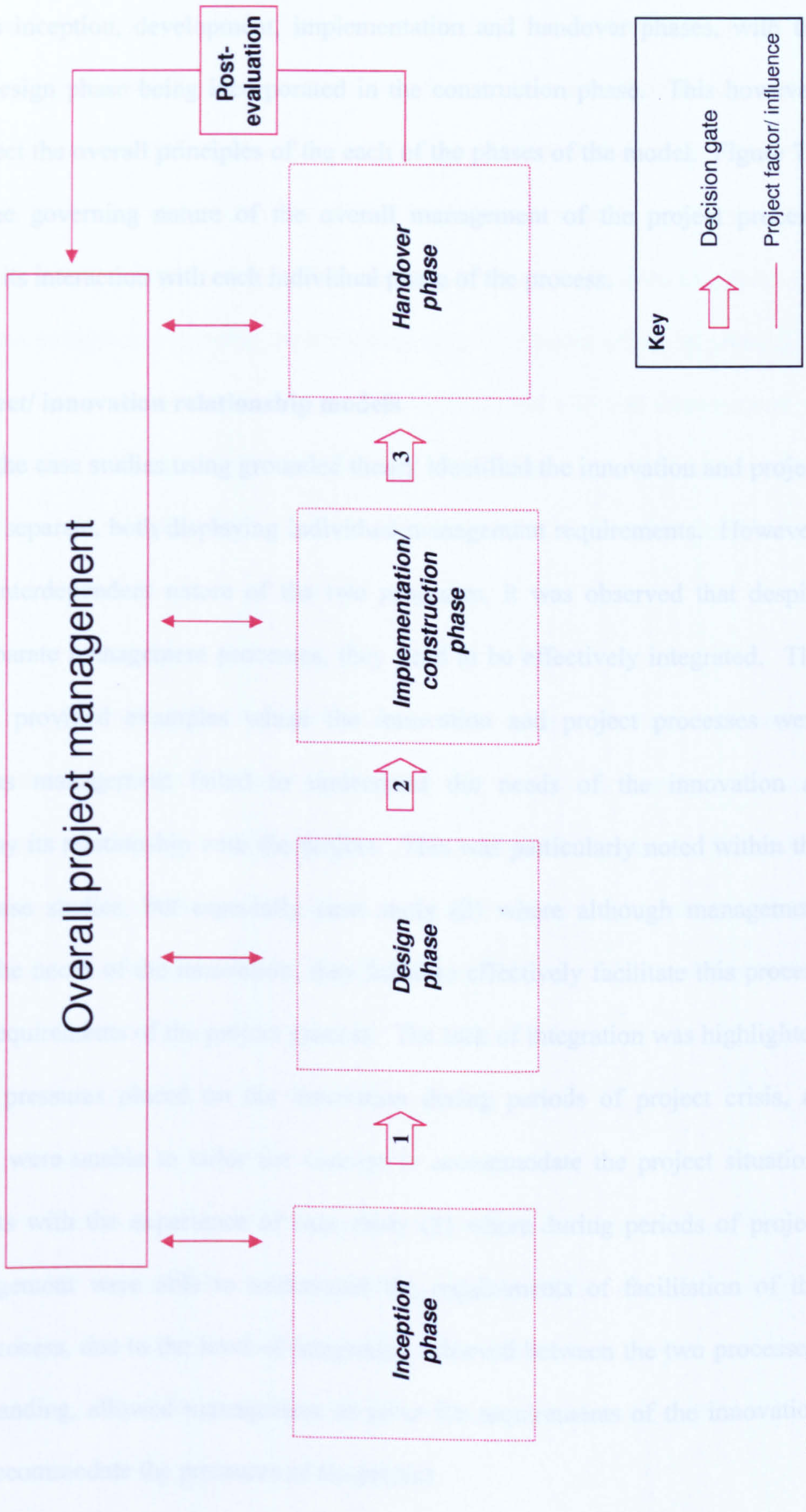


Figure 7.1: Project management process model

design and construction phases. Within these examples, the project process is better described as inception, development, implementation and handover phases, with the traditional design phase being incorporated in the construction phase. This however, does not affect the overall principles of the each of the phases of the model. Figure 7.1 illustrates the governing nature of the overall management of the project process, highlighting its interaction with each individual phase of the process.

7.3 Project/ innovation relationship models

Analysis of the case studies using grounded theory identified the innovation and project processes as separate, both displaying individual management requirements. However, due to the interdependent nature of the two processes, it was observed that despite requiring separate management processes, they need to be effectively integrated. The case studies provided examples where the innovation and project processes were disjointed, as management failed to understand the needs of the innovation as determined by its relationship with the project. This was particularly noted within the partnering case studies, but especially case study (2) where although management understood the needs of the innovation, they failed to effectively facilitate this process against the requirements of the project process. The lack of integration was highlighted through the pressures placed on the innovation during periods of project crisis, as management were unable to tailor the concept to accommodate the project situation. This contrasts with the experience of case study (3) where during periods of project crisis, management were able to understand the requirements of facilitation of the innovation process, due to the level of integration achieved between the two processes. This understanding, allowed management to tailor the requirements of the innovation process, to accommodate the pressures of the project.

Analysis revealed that many of the problems relating to the failure to integrate the management requirements of both processes stem from a failure to understand that the nature of the integration differs depending on the type of innovation. Case study (2) illustrates this lack of understanding in phase 1 of the construction project, as the management failed to recognise that the innovation process was required to govern the project process as opposed to being implemented as a component of it. In phase 2 of the construction project this interaction was recognised, and allowed management to address the problems through the recognition that the innovation process was required to govern the project, as opposed to the other way around, as happened in the previous phase.

This section will present models for each of the innovation types (system, process and component) illustrating the relationships between the project management and innovation in order to aid the theoretical understanding of their integration. The models illustrate the four phases of the innovation process (blue) and their relationship with the four phases of the project process (red), and highlights both the project and innovation management.

- **System innovation**

Chapter 3 defined system innovation as a process governed and implemented from a higher level and then introduced within a project or across a number of projects. Figure 7.2 displays the nature of the integration of the innovation and project processes observed within the analysis, highlighting the relationship outlined in the definition.

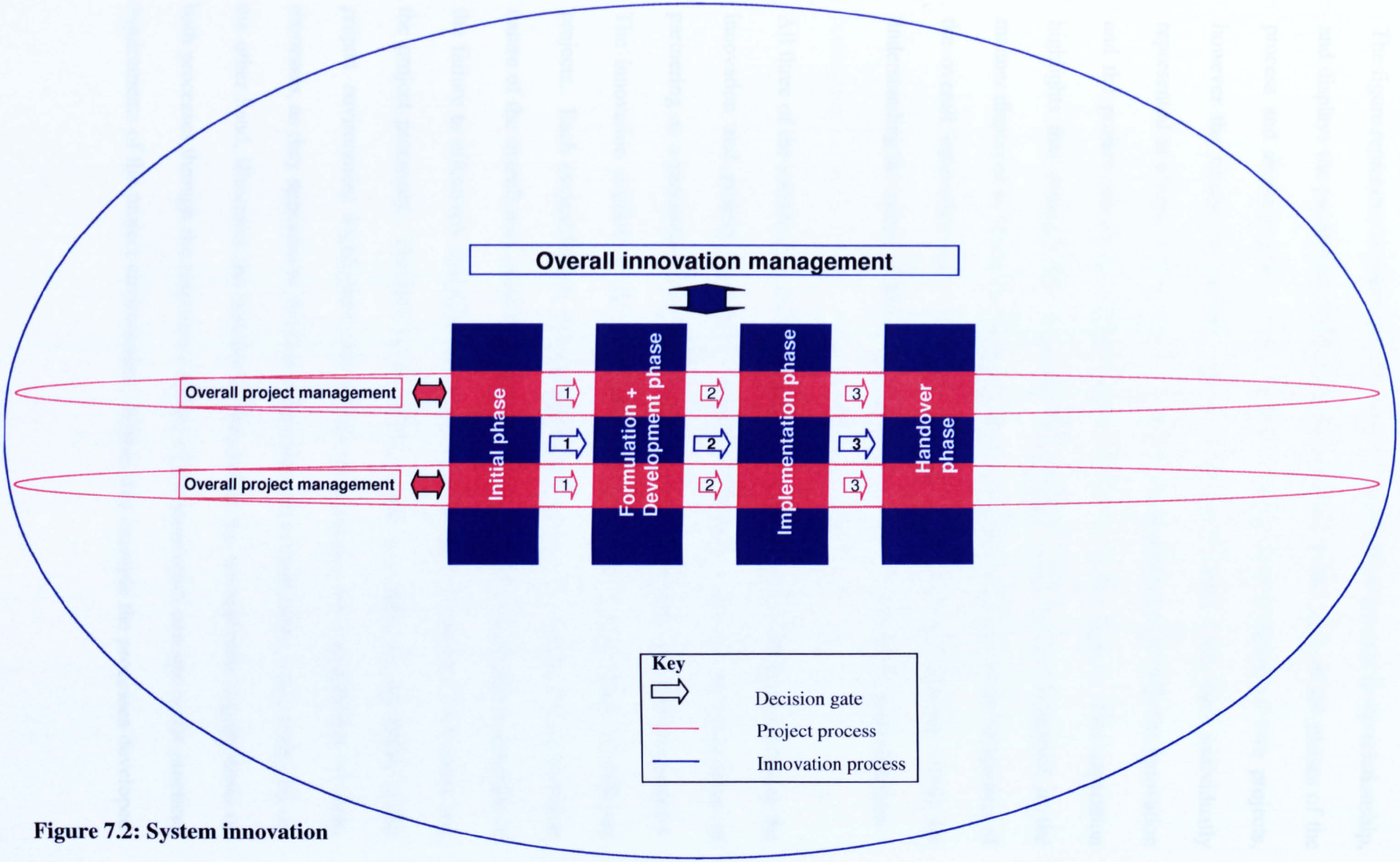


Figure 7.2: System innovation

The figure represents the innovation process as the dominant process in the relationship, and displays the parallel relationship of the processes within each of the phases of the process and decision gates. The figure provides a representation of two projects, however the number of projects can be infinite by nature, with each individually represented as a band running across. The overall management of both the innovation and the project process is displayed as separate within the figure. This separation highlights that although the innovation and project processes are integrated in the manner displayed in figure 7.2, there is a need to outline the nature of the integration of the overall innovation and overall project management of each process. Only by understanding the nature of the integration can the processes follow a shared objective.

All three of the system case studies displayed the nature of this integration between the innovation and project processes. They illustrated the use of the innovation of partnering as a procurement method over a number of different construction projects. The innovation resulted in the same project team working on a series of different projects. Each project has its own management process, in addition to the dominant nature of the overall innovation management. Case study (2) highlights an example of the failure to effectively integrate the overall management of both the innovation and the project processes. The lack of suitability of the innovation for the needs of the project environment highlighted this failure to integrate the management of both processes, as they appeared to develop independent from each other. Case study (3), on the other hand, illustrates the benefits of integrating the management requirements of both processes through the responsive nature of the innovation concept to the practical requirements of the project environment. Within this example the processes developed interdependently and this was reflected in both the suitability and tailored nature of the innovation to the needs of the project.

- **Process innovation**

The definition provided in chapter 3 for the process innovation describes a project that represents the innovation. The analysis of the case studies revealed that the innovation and project processes are shared in terms of the individual phases as well as the overall management requirements, supporting this definition. This is displayed in figure 7.3. Analysis showed that the innovation effectively represented the function of the project. Therefore, the overall management of the project was the same as the overall management of the innovation, and the process was observed to follow the same phases.

The wind turbine case study adopted a standard project management methodology established by the client organisation for the management of the process. Examination of this case study revealed that whilst the phases of the process were constant in function, there emerged a need to support and facilitate the innovation within this process. Within this example the standard project management methodology planned by the organisation naturally accommodated the need to facilitate the innovation due to its manufacturing roots. Case studies such as the reed bed and demolition waste case studies, through their use of project management approaches, required additional facilitation for the innovation that went beyond that of this approach. Construction projects that represent process innovations need to manage the project as the innovation, observing the principles outlined in the previous chapter, and not purely through the adoption of a traditional project management approach.

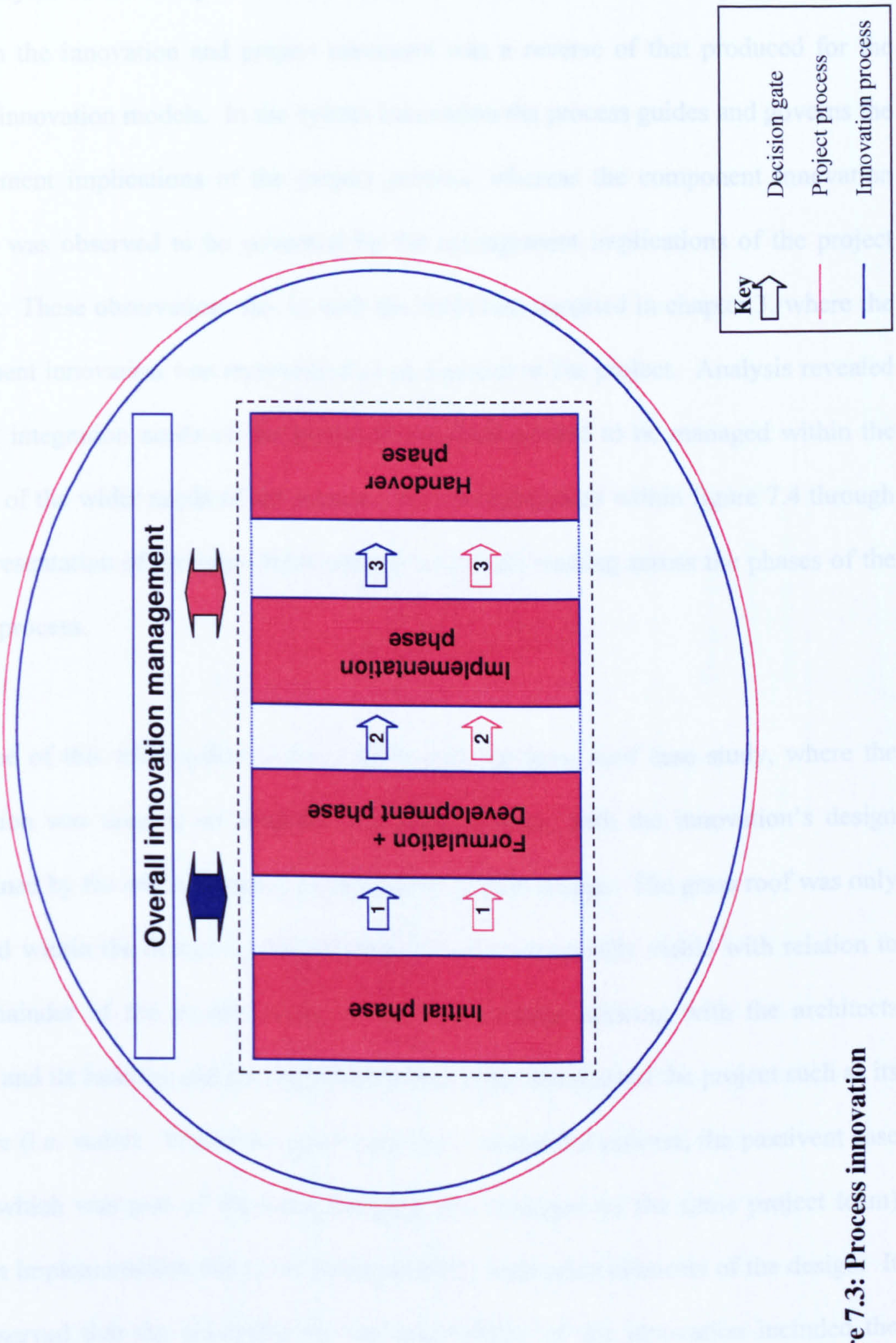


Figure 7.3: Process innovation

- **Component innovation**

The analysis of the component innovation case studies revealed that the relationship between the innovation and project processes was a reverse of that produced for the system innovation models. In the system innovation the process guides and governs the management implications of the project process, whereas the component innovation process was observed to be governed by the management implications of the project process. These observations tie- in with the definition supplied in chapter 3, where the component innovation was represented as an element of the project. Analysis revealed that the integration needs of the innovation process needed to be managed within the context of the wider needs of the project. This is highlighted within figure 7.4 through the representation of the innovation process as a band running across the phases of the project process.

Evidence of this relationship is observed within the grass roof case study, where the innovation was seen as an element of a wider project, with the innovation's design determined by the other elements of the overall project design. The grass roof was only included within the design of the building if, it was financially viable with relation to the remainder of the project costs, it was aesthetically pleasing with the architects design, and its function did not negatively affect other elements of the project such as its structure (i.e. walls). Whilst the grass roof was a successful process, the passivent case study (which was part of the same building and managed by the same project team) failed in implementation due to its incompatibility with other elements of the design. It was observed that the reasoning for the unsuitability of the innovation included the implications that it would have on the use of the grass roof in the design, as it posed technical limitations on the ability to use a passivent system.

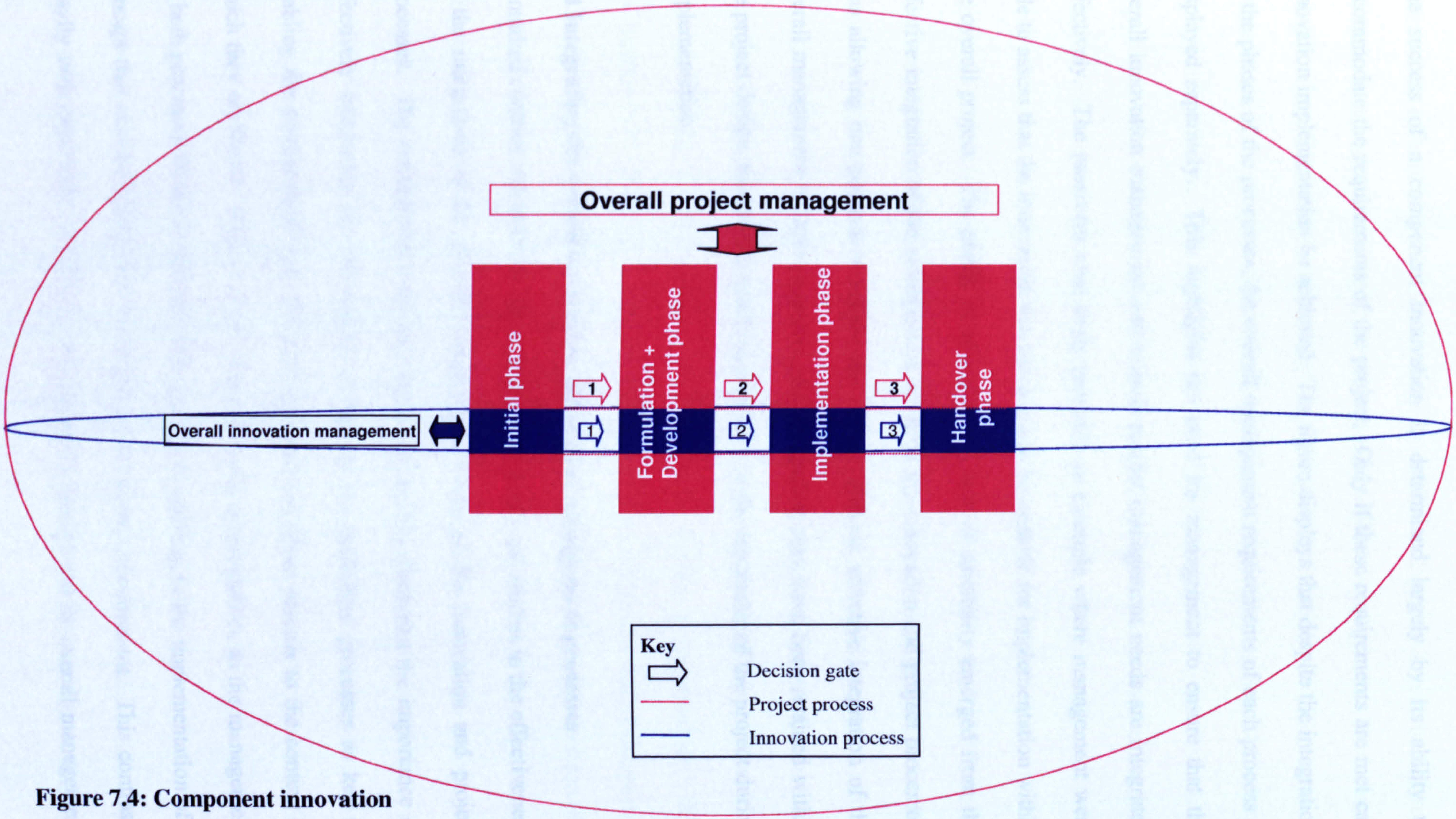


Figure 7.4: Component innovation

The success of a component innovation is determined largely by its ability to accommodate the requirements of the project. Only if these requirements are met can innovation implementation be achieved. The figure displays that despite the integration of the phases of the processes, the overall management requirements of each process is displayed separately. This highlights the need for management to ensure that the overall innovation management and overall project management needs are integrated effectively. The passivent case study provides an example where management were able to assess that the innovation was not going to be suitable for implementation within the overall project. The ability to recognise the lack of suitability emerged from the effective integration of the management needs of the innovation and project processes, thus allowing one process to inform the other. Without effective integration of the overall management of both processes, the innovation may have been retained within the project design, therefore presenting problems to the remainder of the project during implementation.

7.4 Integrating the overall innovation and project management processes

A marked contrast was noted in the experience of some case studies in the effectiveness of the integration of the overall management needs of the innovation and project processes. The contrast between case study (2) and (3) illustrates the importance of effectively integrating the management needs of the individual processes as key to enabling the management team to tailor the needs of either process to the context in which they are found. Case study (2) failed to achieve integration, as the management of both processes failed to interact with each other resulting in the implementation of a concept that was unsuitable for the nature of the project environment. This contrasts heavily with case study (3) where the innovation concept and its overall management process were tailored to the needs of the project and its management needs throughout, due to the recognition by management of the need for process integration. The overall management of both the innovation and project processes provides the direction and governs the nature of the individual phases of each of the processes. Without an effective integration of the overall management of both these processes, the direction of the processes will fail to evolve and develop together, reflective and accommodating of each other's needs.

Assessment of the system, process and component innovation case studies illustrated that although the innovation and project processes share the same generic structure, the nature of the integration of management processes differs depending on the type of innovation. These differences were noted to reflect the distinct relationship that each type of innovation shares with the project process, and highlights that these distinctions require to be understood by management during the integration of the processes. This sub- section will outline a) the nature of the integration of the overall management needs of each of the three types (highlighting the contrasting relationships between the activities and factors of influence for each of the models), and b) relate the implications of this relationship to the nature of the individual phases of the innovation process for each type.

- **System innovation**

a) Nature of the overall management integration

A comparison of the integration of the overall management of the innovation and project processes in case study (2) and (3), illustrates the need for understanding the nature of the relationships between the two processes. The previous section highlighted the governing nature of the innovation process over the project process when considering system innovations. It was apparent when examining case study (2) and (3), that only the later example provided evidence of an understanding of the implications for management of the nature of this relationship, and was able to effectively integrate the management requirements of both processes. Case study (3) illustrated the implementation of partnering as an innovation within a number of individual construction projects, and demonstrated the governing nature of the innovation process over that of the project. There existed little room in practice for the individual construction projects to adapt their management structure away from that laid out through the adoption of the innovation. Case study (2) by contrast, due to the lack of integration of the overall management of these two phases, illustrated an example where the project needs were allowed to supersede those of the innovation during periods of project crisis. This section presents the observed implications of this relationship on the integration of the activities and influencing factors of the integration of the overall management of both the innovation and project processes.

Analysis revealed that the structure of the integration of the activities and influencing factors for achieving successful overall management within the system case studies, reflected the governing nature of the innovation process over the project process. Figure 7.5 presents the relationship between the elements of the innovation and project for the integration of the overall management of both processes. Analysis identifies that the overall innovation management control system, selection process and cultural/ team factors are innovation elements within the integrated overall management. For a system innovation the selection process is an activity associated with the innovation as opposed

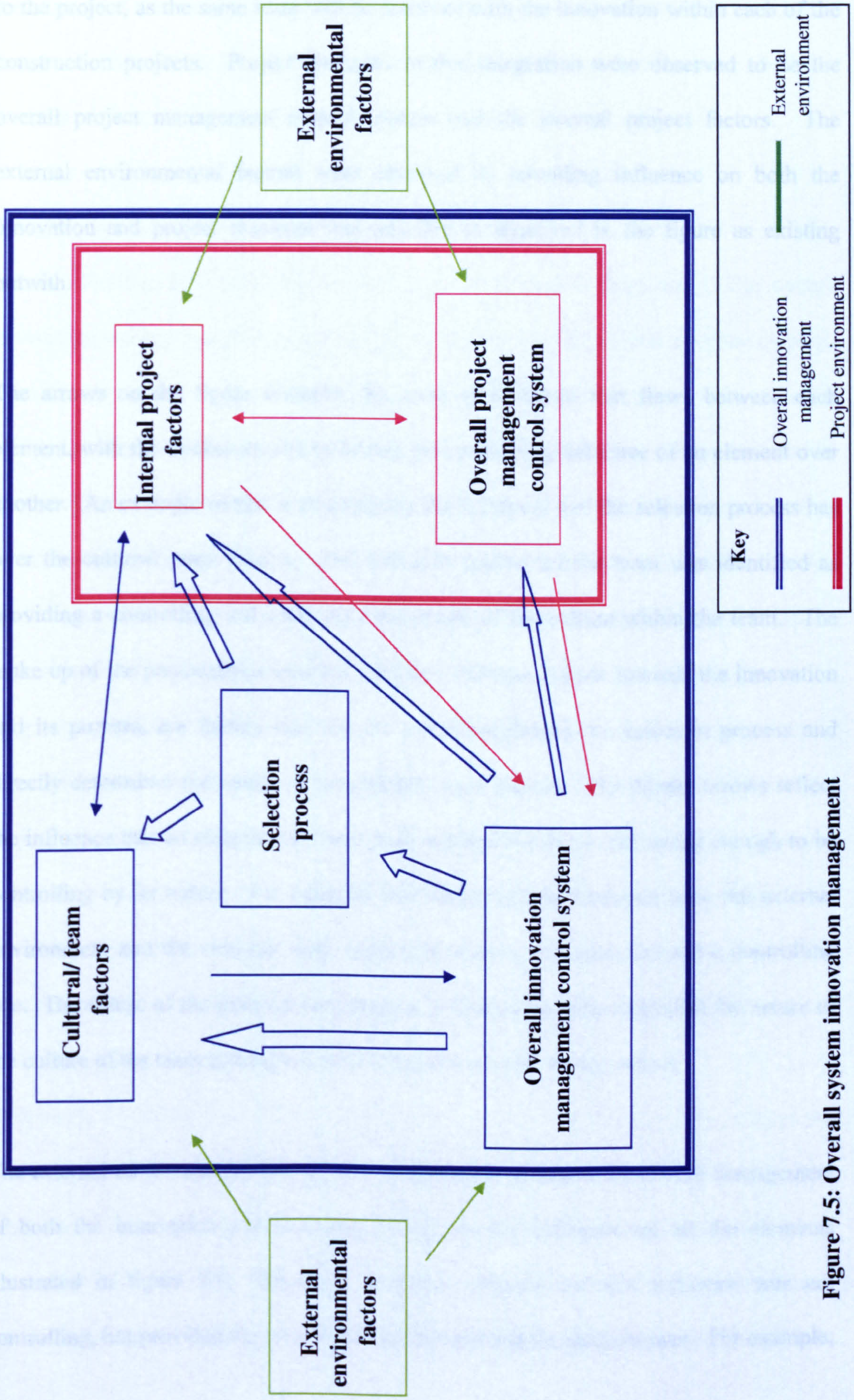


Figure 7.5: Overall system innovation management

to the project, as the same team will be involved with the innovation within each of the construction projects. Project elements of this integration were observed to be the overall project management control system and the internal project factors. The external environmental factors were observed as providing influence on both the innovation and project elements was and this is displayed in the figure as existing outwith.

The arrows on the figure illustrate the level of influence that flows between each element, with the thicker arrows reflecting the controlling influence of an element over another. An example of this is observed by the influence that the selection process has over the cultural/ team factors. The selection process of the team was identified as providing a controlling influence over the nature of the culture within the team. The make up of the personalities selected, and their cultural outlook towards the innovation and its process, are factors that can be controlled during the selection process and directly determines the nature of the cultural/ team factors. The thinner arrows reflect the influence that an element can have over another, but this is not strong enough to be controlling by its nature. For example, the thinner arrow displayed from the external environment and the cultural/ team factors, illustrates influence, but not a controlling one. The nature of the external environment will not determine or control the nature of the culture of the team although it will have a directive influence over it.

The external environmental factors were identified to influence the overall management of both the innovation and the project, and exerted influence on all the elements illustrated in figure 7.5. However, analysis revealed that this influence was not controlling, but provided the environmental background for each element. For example, the nature of the industry's culture and the facilitating nature of the government's support for the concept provided a positive influence on each of the elements, whether it was seen as innovation or project based.

A management control system was identified to exert control over the influencing factors affecting the overall management of the individual processes. The overall innovation management control system was observed to exert control over the cultural/ team factors, and the activities of the selection process (which were identified as innovation elements within the integration), but also governed the nature of both the project elements identified. The activities of the overall innovation management control system, whilst exerting influence on all the elements (with the exception of the external environmental factors), is influenced by the other elements, however none exert a controlling influence over its function. The nature of the arrows outlining the relationship between the overall innovation management control system and the remaining elements, illustrates the governing nature of its function, particularly over the project elements. The analysis observed that whilst the overall project management control system exerts an influence of control over the internal project factors, the internal project factors can only provide influence on this system, but will not exert control over it.

Case study (3) illustrates the successful function of the overall innovation management control system, in defining the criteria by which the selection process for the team was conducted, therefore determining the nature of the cultural/ team environment. A controlling influence was also evident over the cultural/ team factors directly, with evidence being supplied by the facilitation activities over the culture of the team towards the innovation concept in case study (3). The management employed workshops and meetings to facilitate the feelings of risk and unfamiliarity over the use of the innovation.

The governing nature of the management integration of the innovation over the project is represented in the figure by the controlling influence of the overall innovation management control system over the internal project factors and the overall project management control system. Within a successful example of an integrated management approach, such as case study (3), it was observed that the influence of control can only be exerted from the overall innovation management control system (and therefore through the selection process), to the project elements. Within this example the internal project factors and the overall project management control system can exert influence on the innovation elements such as the overall innovation management control system, cultural/ team factors and the selection process, but this influence would not be controlling by nature. The influence only informs these elements and helps to shape them, but would not control or govern their nature. As a result, the management of the innovation was able to retain control over the management of the project during integration, and allowed the needs of the project to inform the nature of the innovation. By ensuring this, a suitable innovation tailored to the needs of the project will emerge, with the project informing and directing the innovation as opposed to controlling and threatening it.

The example of case study (2) provides a direct comparison to the successful integration achieved in case study (3), and highlights the problems associated with the failure of effectively integrating the elements of the overall management of the two processes.

The failure of case study (2) to understand the governing nature of the innovation process over the project process resulted in the failure of management to limit the influence of both the project elements (internal project factors and overall project management control system) to merely directing and informing the innovation elements. The consequence of this failure was evident during periods of project crisis, where the negative nature of the internal project factors caused by the crisis (cost, time and cultural issues within the team), and the inability of the overall project management control system to facilitate the impact of the crisis, were allowed to exert a controlling influence over the innovation elements (cultural/ team factors and the overall innovation management control system). The pressures observed within the project environment, due to the failure to effectively integrate the overall management of the innovation and project processes, resulted in the abandonment of the innovation and its replacement with a more traditional form of procurement in order to solve the crisis within the project. Effective integration would have allowed these project influences to only inform and direct the nature of the innovation elements, and would not have resulted in the abandonment of the innovation. Case study (2) highlighted the vulnerability of the system innovation, when the management needs of the project are viewed as governing that of the innovation.

b) Implications of relationship on the innovation process

Chapter 6 identified the individual phases of the innovation process, and outlined the generic activities (phase process and management control system) and factors of influence (external environmental, internal project and cultural/ team factors) of each. During the analysis, it became apparent that the significance of the activities and factors of influence identified varied in reflection of the context of the case study (the attributes of both the project and the innovation). The implications of establishing the distinctions in the nature of the integration between the innovation and the project processes for the different types of innovation, poses the question of how this impacts on activities and factors of influence of the individual phases of the innovation process.

Figure 7.6 presents a detailed breakdown of the significant activities and factors of influence identified for the system innovation, in the form of an innovation process model. The model displays the three decision gates and four phases outlined in the research model in chapter 6, and the overall innovation management phase and selection phases outwith the innovation process, in order to represent their wider influence on the process and the fluid nature of its interaction. The model displays vertically the activities or factors of influence of most significance to the system innovations, for each element within each phase. This model pulls together the generic understandings of chapter 6, with the contextual implications of managing the system innovation type.

An assessment of the system innovation process model in figure 7.6 provides evidence suggesting that the activities and factors of influence identified as significant for the system innovation type were reflective of the governing nature of the innovation process over that of the project process. Assessment of the overall innovation management of the innovation process establishes the top- down approach of management reflective of the nature of the integration. The focus on activities in the phase process such as ensuring the involvement of senior management, engaging the team, highlights a top- down management flow between the top- level and the remainder of the team. Case study (3) highlights this flow, with top-level management within the client body introducing the innovation for use, and implementing it within a

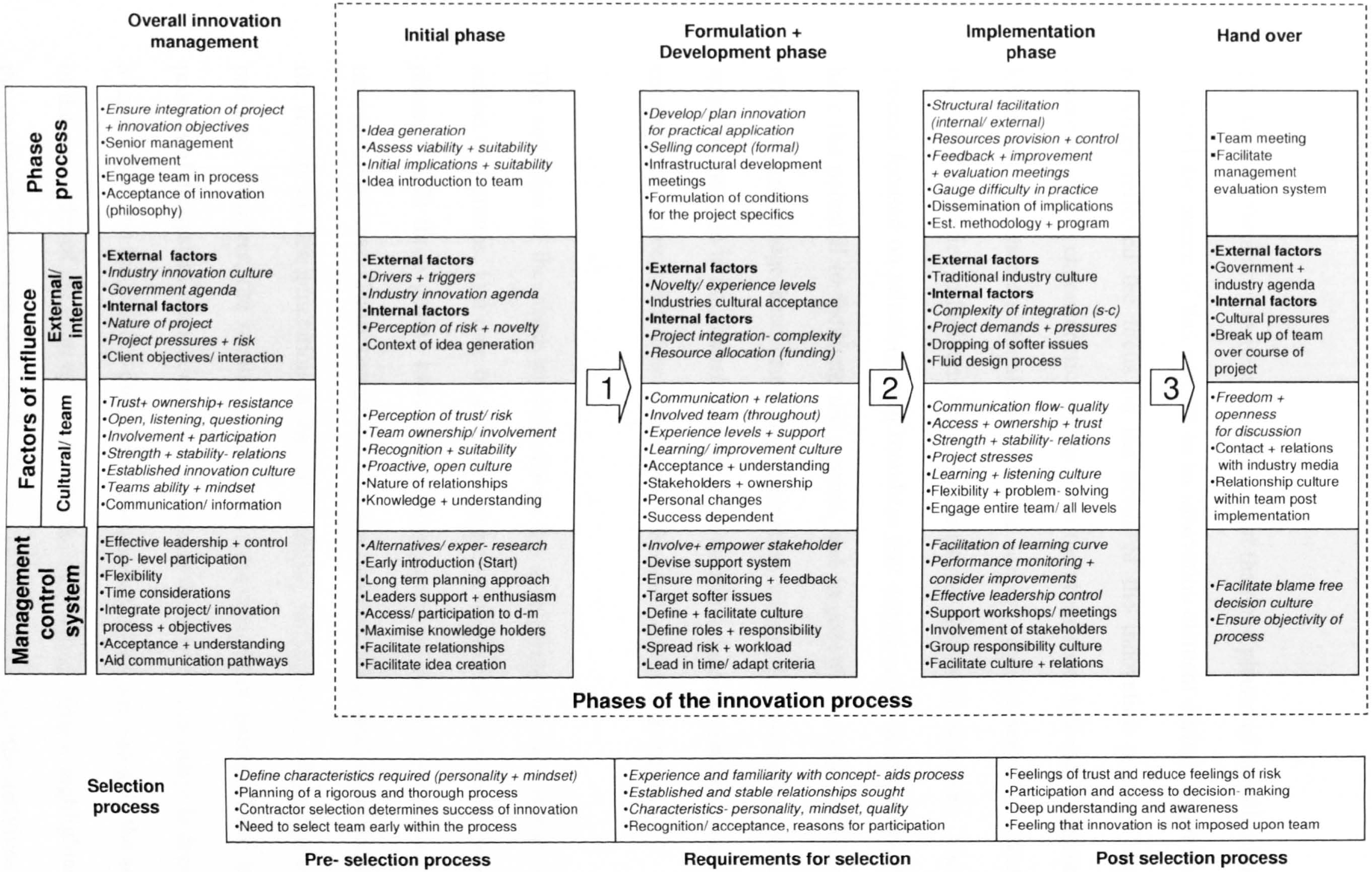


Figure 7.6: The System Innovation Process Model

number of construction projects. Success was gained in this example through effective leadership and structure driven by top- level management.

The focus of the activities identified in each of the three phases of the selection process, reflected the nature of this process as an innovation element during integration. These activities reflected the focus on the needs of the innovation process, such as the definition of the characteristics of the team members (pre- selection), assessments on levels of experience and familiarity with the concept (requirements for selection), and the use of activities to facilitate feelings of trust and risk (post selection). The selection process focused on selecting team members that displayed cultural characteristics that have the potential to facilitate the process, and to provide the selected team with an effective knowledge base prior to participation within the innovation process. The selection process is not focused towards the traditional considerations associated with construction projects, but instead focuses on the needs of the innovation.

The activities of the phase process across the four phases of the innovation process reflect two groups, 1) a core of activities geared towards the function of the individual phase, and 2) those geared towards the engagement of the rest of the team with the innovation process. Those concerned with the function of the individual phase (such as the activity of idea generation in the initial phase), are common within any innovation process. However, the second group reflect the top- down nature of the innovation process of the system innovation. The success of the system innovation is dependent, to a large extent, on the ability of top-level management to engage and gain the acceptance of the remainder of the team of the need for the innovation. This is highlighted through the comparison between case study (2) and (3). The context of the activities aimed at encouraging this, change as the process moves through the phases but the principle remains. The significance of activities associated with this principle reflects the governing nature of the innovation over the project process, and the need for top- level management to integrate culturally the remainder of the team behind the goal of the innovation.

Assessing the nature of the factors of influence within each of the individual phases identifies that although the context varies depending on the function of the phase, themes exist across the process reflective of the top- down nature of the process. The internal project factors throughout the innovation process focused on the pressures and issues associated with the integration of the individual projects with the innovation. The emphasis noted in the significance of these factors was the need for the projects to adjust to the specifics of the innovation, and this reflects the nature of the integration between the innovation and project processes within this chapter. The cultural/ team factors across the innovation process for the system innovation type, also reflects factors associated with the need for top- level management to engage and convince the team of the merits of using the innovation within this context. Although many of these factors are contextual to the function of the individual phases, common themes were identified such as the levels of involvement, ownership, and knowledge that the team enjoys for the innovation. The external environmental factors were noted to be largely background factors to the innovation process, and not specific to a particular type of innovation.

The management control system was identified in chapter 6 as performing the function of facilitating the factors of influence to enable the phase process to perform its function. The activities noted across the system innovation process focused on an approach based on facilitating the knowledge base of the team, and ensuring their involvement in the process. These activities aim to assist the team to gain ownership and understanding as to the purpose of the innovation, whilst lowering their levels of resistance towards it. The case studies illustrated that successful facilitation for system innovations is achieved through a focus on leadership and the implementation of a structured and understandable approach to facilitation throughout the process. These aspects are strongly associated with the top- down nature of the management approach, and the dependency on gaining the engagement and acceptance of the remainder of the team for achieving a successful process.

- **Process innovation**

a) Nature of the overall management integration

The representation of the innovation and project processes as coexisting in figure 7.3, determines that the overall management of both processes are already integrated. Indeed an assessment of the three process case studies revealed that successful overall management of the innovation and project processes is achieved when management understand that they involve the same elements, and that neither process is governed by the other. This is perhaps a logical statement, as the innovation process was identified as being the project process also. Figure 7.7 identifies the nature of the overall management for the process, shows the nature of the influence between the elements. Observed were the presence of activities such as the overall management control system, the selection process, and the factors of influence of the external environment, internal project and the cultural/ team. It was noted that the relationship between the elements involved the overall management control system exerting the controlling

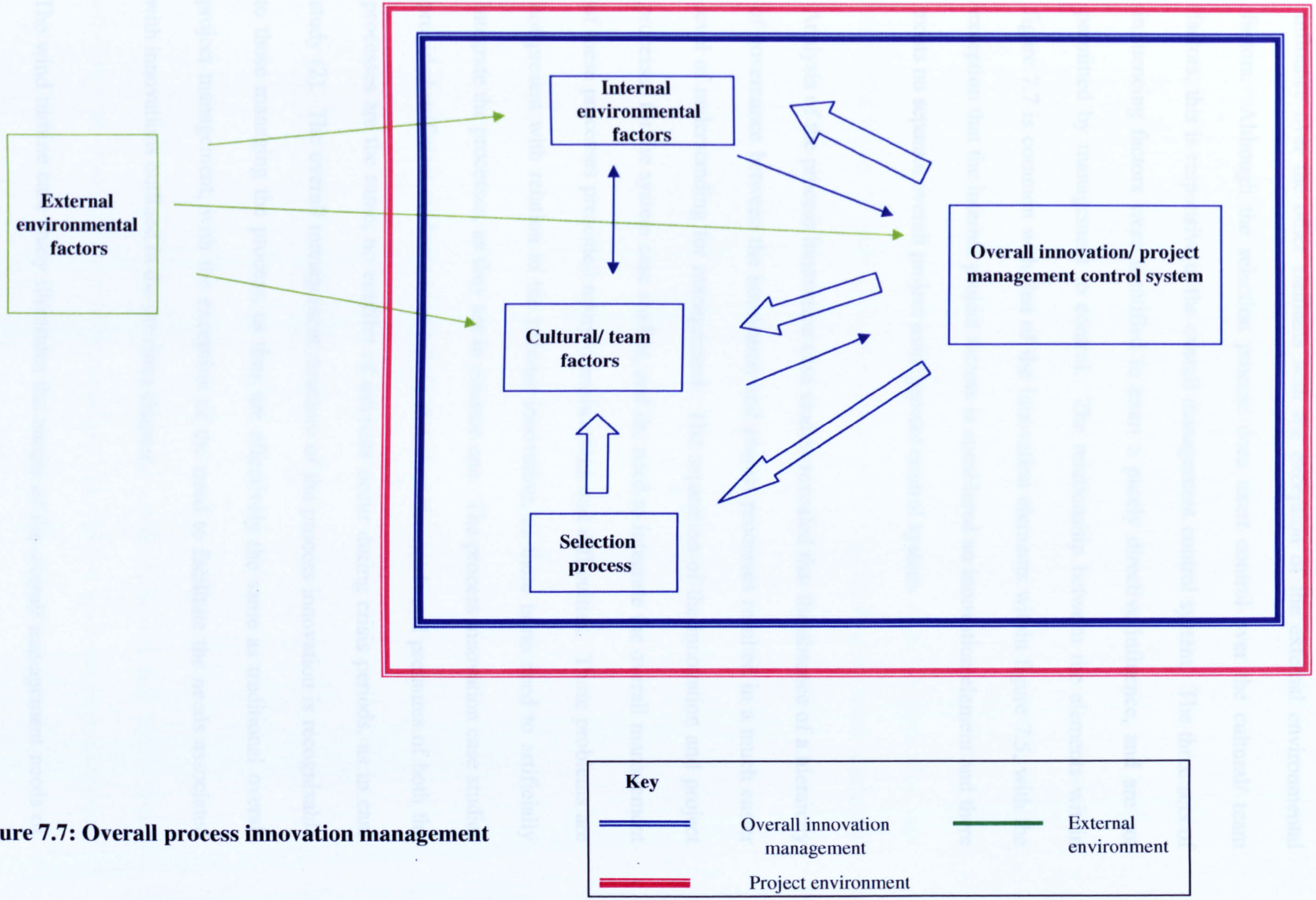


Figure 7.7: Overall process innovation management

influence over the other elements with the exception of the external environmental factors. Although the selection process does exert control over the cultural/ team factors, this is responsive to the overall management control system. The three sets of influencing factors were identified to exert a purely directive influence, and are not permitted by management to control. The relationship between the elements within figure 7.7 is common with that of the innovation elements within figure 7.5, with the exception that the internal project factors is considered an innovation element and there exists no separate overall project management control system.

Analysis of the process innovation case studies revealed that the absence of a hierarchy of governance between the innovation and project processes resulted in a much easier level of understanding for management. The separation of the innovation and project processes for the system case studies, and the need to integrate the overall management of these processes presented many complications and difficulties. These problems are not present with relation to the process innovation, as there is no need to artificially integrate the processes, as they are in essence one. The process innovation case studies provided sufficient evidence to conclude that since the needs and pressures of both the processes are the same, no conflict of interests occur during crisis periods, as in case study (2). The overall management structure of the process innovation is recognisable to those managing the process, as they are effectively the same as traditional overall project management, with the exception of the need to facilitate the needs associated with innovations outlined in the previous chapter.

The wind turbine case study illustrates the nature of the overall management needs of the process, through the adoption of a standard project management methodology that was familiar to all team members. The manufacturing background of those managing the process meant that structurally and culturally the use of this methodology naturally facilitated the needs of the innovation. This contrasts with the demolition waste case study, where the adoption of a traditional project approach to managing the process failed, in the initial phases, to facilitate the needs of the innovation. Analysis showed that the construction culture is not naturally supporting towards the needs of innovation within the project process in the manner that the manufacturing organisation was. Additional facilitation of the knowledge base of the team towards the innovation was recognised within the demolition waste case study. Highlighting the need within the overall management of the process in construction to incorporate the additional needs of the innovation process outlined in previous chapter. The demolition waste case study recognised this issue early, and adjusted to incorporate these needs.

b) Implications of relationship on the innovation process

Figure 7.8 presents a detailed breakdown of the significant activities and factors of influence identified for the process innovation type, using the same format for the system innovation. The previous discussion outlined for the process innovation the need to integrate the innovation and project processes as one. Assessment of the overall innovation management of the process innovation identifies this need within its activities and factors of influence. Evaluation of the significant activities identified in both the phase process and the management control system revealed considerations constant within any project process. The case studies revealed that whilst these activities were consistent with traditional project management considerations, additional emphasis is placed on them to accommodate the issues of uncertainty caused by the innovation.

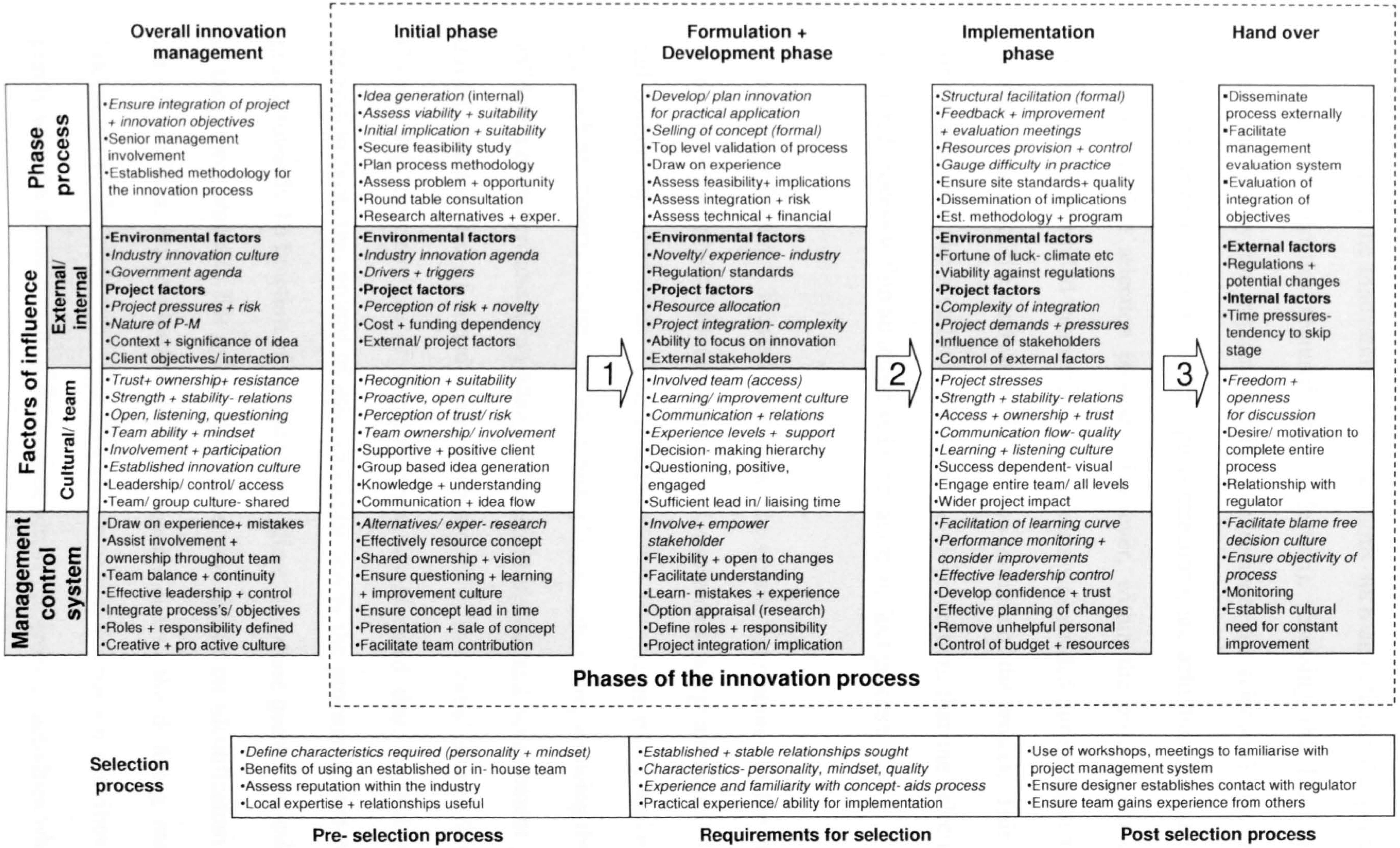


Figure 7.8: The Process Innovation Process Model

The activities identified as making up the three phases of the selection process represent a traditional project selection process, and the need to provide additional facilitation in order to support the innovation. Considerations such as defining the personality and mindset characteristics required (pre- selection), assessing the level of practical experience/ ability for implementation (requirements for selection) and ensuring the team gains experience from others (post- selection), are activities that take place in a traditional project selection process. However, within the process innovation case studies it was identified that additional emphasis was needed during these activities on the requirements of the innovation, in addition to those of the project. This assessment corresponds with the identification in the previous section, that the selection process was a tied process within an integrated innovation/ project process.

Assessment of figure 7.8 reveals that unlike the system innovation type the management of the innovation process for process innovations needs to adopt a mixture of top- down and bottom- up approaches. This is noted within the phases where variations in the approach are observed across the individual phases, with examples being the top- level validation of the process as an activity of the formulation and development phase (top- down) and the use of round table consultation in the initial phase (bottom- up). Considering the activities of the phase process revealed that, as with the system innovation type, two groups of activities exist across the process, a core of activities geared towards the function of the individual phase, and those geared towards the needs of the project process. The system innovation type shared the identification of the first set of activities, but contrasted with the second due to the differing nature of the integration of the processes. The process innovation focuses on activities associated purely with the development of the project across the process, activities which are not specific to the innovation as in the system innovation type. The activities identified in each of the phases should be considered as good practice within any project process, however analysis of the case studies revealed that the level of emphasis applied to each of the activities is enhanced when considering an innovation. The activities of the phase process within each of the individual phases are common for both the project and innovation process for the context of the process innovation type.

The factors of influence identified as significant across the phases of the innovation process predominantly related to the threat posed through a lack of understanding and certainty regarding the practical implications of the innovation. The external environmental factors are observed to be predominantly background factors common to any innovation process as in the system innovation, however additional emphasis is placed on the need for the innovation to comply as a project with regulations and standards. The increased significance of factors associated with this issue for process innovations illustrates the contrast in the integration between the innovation and project processes because of the need for the innovation to comply. The internal project factors reflect largely a traditional set of project factors, although additional emphasis is placed on a need for awareness that the innovation does not harm traditional project concerns such as cost, fitness for purpose and complexity. The cultural/ team factors identified as an influence on the phase process were observed to focus on aspects of uncertainty created through the use of the innovation as a project. Factors such as levels of ownership, involvement, engagement and participation in decision-making activities with the process were identified as influencing the performance of the phase process, across the phases. The case studies illustrated a correlation between low levels of these factors and an increase in the level of uncertainty and lack of understanding of the innovation and its implications. Team members are familiar with the structure of the activities associated with the phase process, but their participation is limited if they are uncertain of what they are dealing with. This reflects the integrated nature of the project and innovation processes for the process innovation type.

The management control system across the phases reflected the need to facilitate the integration of the innovation within the activities of the project. The activities of the management control system were geared to supporting the activities of the project process, by ensuring that additional emphasis was placed on reducing the levels of uncertainty surrounding the implications of the innovation. Activities of facilitation, such as ensuring that a sufficient lead in time is provided during the early phase of the process to aid the team in getting ready for its implementation, are necessary for reducing the feelings of uncertainty. The case studies identified the significance for process innovations of supporting the team culturally to allow them to engage in the activities of the phase process. Evidence revealed that the nature of the relationships and communication pathways between team members, and the overall mindset and outlook of the team towards innovation, greatly influenced the team's levels of engagement and understanding of innovation. Successful facilitation of the activities of the phase process from the factors of influence needs to involve activities targeting these issues, structured around the activities of the phase process and thus allowing the team to engage with the project process as an innovation. Such a process is not a top-down or bottom- up approach, but is an integrated approach with both the innovation and project processes occurring as one.

- **Component innovation**

a) Nature of the overall management integration

Analysis of the component innovation case studies revealed that a hierarchy of governance exists with relation to the integration of the overall management of the innovation and project processes. Figure 7.4 outlines the governing nature of the project process over the innovation process and displays the overall management of each process as separate. Analysis of the grass roof case study highlighted the need for effective integration of the overall management needs of both processes. The grass roof was a significant component of the project design, and its success was dependent on its integration with the other elements of the design. Only by achieving the integration of the management of both processes can the innovation develop in a manner reflective of the needs of the wider project. This case study illustrated the need for the innovation to be adaptable and flexible to the changes within the project, as it was the project that was the governing influence on the innovation. The passivent case study illustrates an example where the needs of the project superseded that of the innovation and, due to the inability of the innovation to accommodate requirements of the project, as it was dropped at the design phase.

Figure 7.9 outlines the nature of the integration of the overall management of both the innovation and project processes, demonstrating the governing influence of the project elements over the innovation. It can be observed that the relationship between the project elements is constant to that of the integration observed for the process innovation in figure 7.7, but figure 7.9 differs through the inclusion of a separate

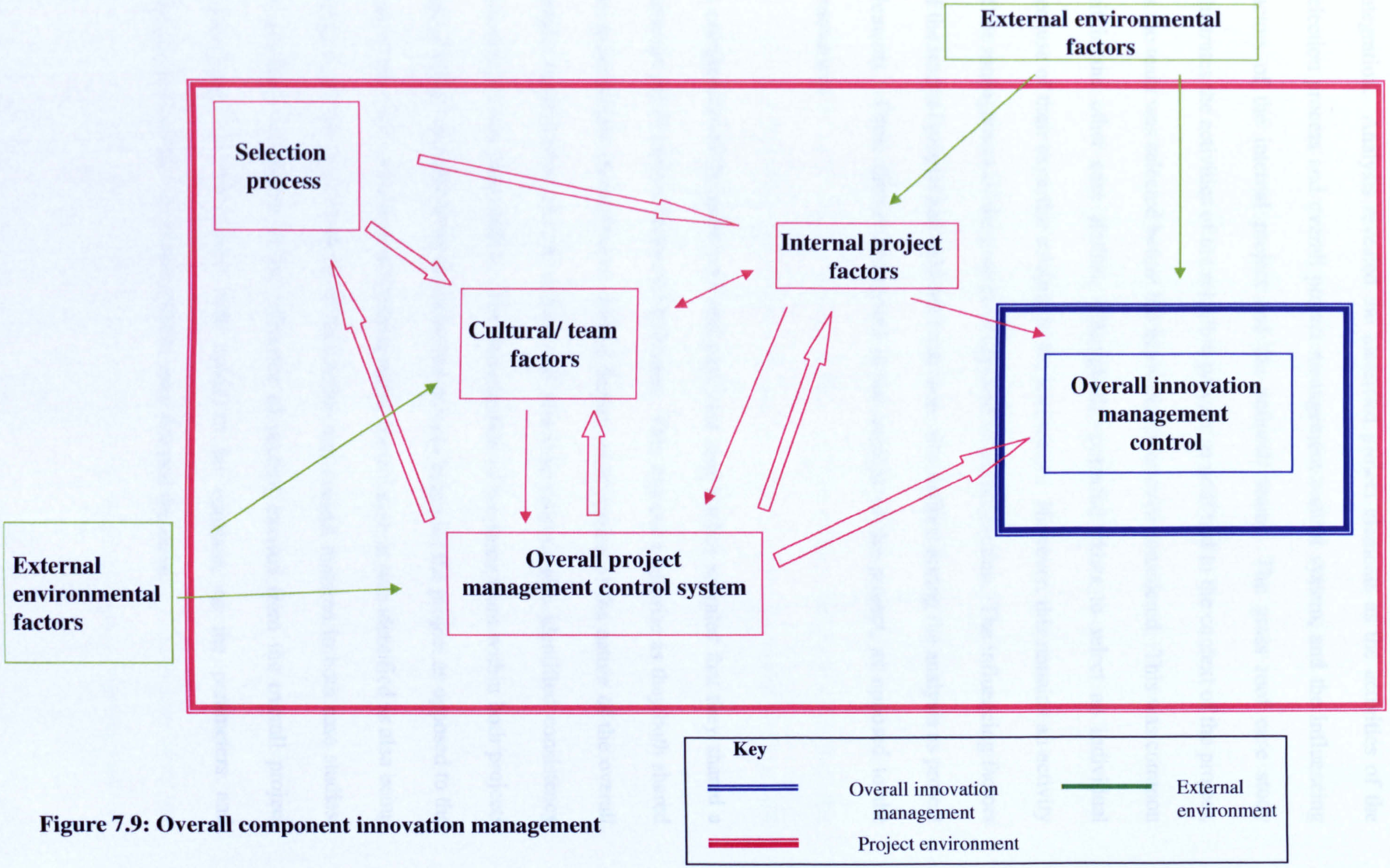


Figure 7.9: Overall component innovation management

innovation element displaying the controlling influence of the project elements during integration. Analysis revealed the identified project elements as the activities of the selection process and overall project management control system, and the influencing factors of the internal project and the cultural/ team. The grass roof case study illustrates the activities of the selection process as confined to the context of the project, as the team was selected before the innovation was even considered. This was common within the other case studies, although the potential exists to select an individual because of their expertise relating to the innovation. However, this remains an activity of the management of the project as opposed to the innovation. The influencing factors of the internal project and cultural/ team were also defined during the analysis as project elements. These factors are rooted in the context of the project, as opposed to the innovation.

A comparison of the grass roof and passivent case studies revealed that they shared a common set of project factors of influence. This was not a surprise as they both shared the same project environment. Indeed further examination of the nature of the overall project management control system and selection process also identified consistency between the two case studies. The participation of the same team within both projects was observed to result from the selection process being for the project as opposed to the innovation. The overall project management control system was identified as also being constant, as the same methods of facilitation and control featured in both case studies. In addition, the nature of the influence of control exerted from the overall project management control system was noted to be constant, as the parameters and requirements of the innovation process were deemed the same.

The comparison revealed that it was the role of the overall innovation management control system to adjust the nature of the innovation process to tailor the needs of the innovation to these requirements. The overall innovation management control system was able to influence the overall project management control system; however, this was noted to only be directive and not controlling. Evidence of this emerged within the grass roof case study where modifications were made to the structure of the building in order to accommodate the nature of the innovation. It is clear however, that the project was under no requirement to accommodate the innovation if it was not seen as appropriate. The passivent case study demonstrates an example where an innovation was dropped due to the inability to accommodate it within the remainder of project design. The roof insulation material case study also follows this pattern of integration, as the requirements of the project, define and determine the parameters that the innovation, whether it be factors such as cost, time and quality, or related to the effect on other elements of the design.

An example of the failure to integrate effectively the overall management of both these processes did not emerge during analysis. The passivent case study, although failing as an innovation to be included in the project, provided an example of successful management of the integration between the two processes. The termination of the innovation's use within the project was based on its incompatibility with the other components of the design. This judgement by management represents the successful governance of the project's interests over those of the innovation. Failure to achieve this relationship potentially could result in the implementation of an innovation that was inappropriate for the project, or involved considerable expense in accommodating the innovation at the expense of the other components of the project. Ensuring that the project has a controlling influence over the innovation ensures that such conflicts of interest will not emerge.

b) Implications of relationship on the innovation process

Figure 7.10 presents a detailed breakdown of the significant activities and factors of influence identified for the component innovation type displayed in the same format as the other two types. The previous discussion outlined the innovation as an element of the wider project, with the project process governing that of the innovation process. The overall innovation management of the process reflects the bottom- up approach with relation to the project process. Such an approach is reflective of the nature of the governance of the project process over the innovation process. Those managing the innovation process require to convince the projects top- level management of the merits of considering and implementing an innovation as an element of the project. Assessment of the component case studies revealed that successful management of the overall process requires an appreciation that the innovation requires to be accommodated by the other elements of the project. The grass roof case study provides an example where recognition of this need aided the integration of the innovation as an element of the project. The assessment and awareness of the implications of the grass roof on the other elements of the project provided the basis for informed decision-making regarding its inclusion and potential use within the project.

The activities of the three phases of the selection process represent those of a traditional project selection process. The previous discussion identified the selection process for component innovations as being a project element of the overall management of the process. Analysis of the case studies backed this assertion, through the identification

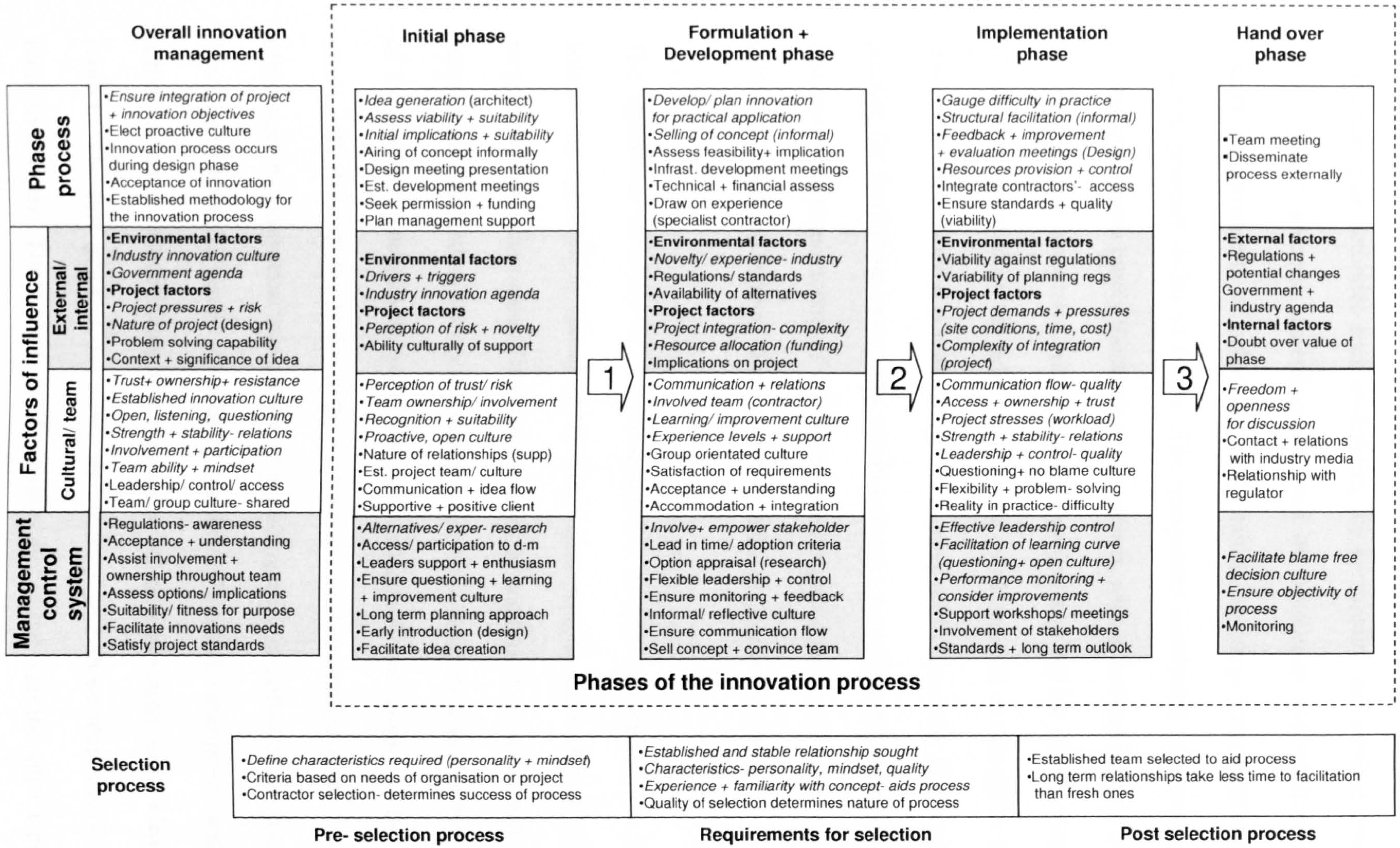


Figure 7.10: The Component Innovation Process Model

that the objectives of the selection process were geared towards the selection of a team for the project and not the innovation process. Although similar to the process innovation type, activities such as defining the personality and mindset characteristics (pre- selection process), assessing the level of experience and familiarity with the concept (requirements of selection) and establishing long- term relationships (post selection process), differ in focus. The component innovation represents a selection process that targets purely the needs of the project, with selection based on a wide array of considerations associated with the overall project and not the needs of one element. Within the case studies, the selection process was identified to take place prior to the innovation process even commencing. The grass roof case study illustrated that best practice for facilitating innovation within a project focused selection process, requires that one of the requirements of selection would involve the consideration of the cultural ability to accept and support innovation within the project environment.

The significant activities of the phase process for process innovations reflects the bottom- up approach to managing the innovation process as an element of the wider project process. Examples of this are provided by looking at activities such as seeking permission and funding during the initial phase to develop the concept from top- level of the projects management, and ensuring the standards and quality of the innovation meets with those of the wider project during the implementation phase. As with the other types of innovation, two groups of activities were identified in the phase process, 1) a core of activities geared towards the function of the individual phase, and 2) a set of activities aimed at facilitating the integration of the innovation as an element of the project. The first group of activities are constant with those identified for the other innovation types. The second set of activities contrasted with the other types and was reflective of the governing nature of the project process over that of the innovation, as it involved ensuring that the innovation satisfied the criteria set out by the project. This includes a focus on activities such as assessments of the feasibility, standards and quality of the innovation within the project. Emphasis was to be placed on activities such as planning and infrastructural development. For the successful implementation of the component innovation there is a need to ensure that the innovation is compatible with the other elements of the project. The passivent case study presents an example where prior to implementation, the innovation was disruptive to other elements of the project, and was rejected on that basis.

The factors of influence identified as significant across all the phase of the innovation process as shown in figure 7.10, and reflect in nature the governance of the project process over that of the innovation. Although many of the external environmental factors were identified to be common with the other types of innovation, as they reflected the influence of background factors, there existed a focus on how the innovation is integrated into the project. An emphasis on the influence of potential alternatives available to the innovation, and the nature of the regulations surrounding the innovation, was noted. The internal project factors identified as significant were observed to focus on issues relating to the level of complexity represented by accommodating the innovation as a component of the project. The implications of other elements of the project provide a significant influence on the component innovation, in a manner that is not possible for system innovations, due to its reliance on the project for governance. The cultural/ team factors identified are observed to relate to the need to engage the project team within the innovation process. The grass roof case study provides an example where the project team were involved throughout the innovation process. This allowed for a sense of ownership to evolve for the concept, thus aiding its inclusion within the overall of the design of the project. Factors such as the level of involvement, the nature of the communication pathways, and the degree of access that the team can gain to the innovation within the project, were observed to influence the success of the component innovation process. The desire of the project team to culturally accommodate and consider innovation, was also observed to be of influence.

The need to facilitate the integration of the innovation as an element of the project were observed to be significant activities across the innovation process for the management control system reflect. Two groups of activities were identified, 1) those relating to cultural facilitation, and 2) those related to the structural facilitation of the process. The significance of the influence of factors associated with the cultural integration of the innovation within the project process highlights the need to facilitate this integration during the phase process. Activities associated with the facilitation of the levels of knowledge of, involvement with, and communication between the project team and the innovation were identified as being necessary to aid this integration. The facilitation of a questioning culture within the project team was identified as aiding the cultural facilitation of the phase process. Assessment revealed that many of the activities identified as significant for the management control system were related to assisting the phase process through structural facilitation. Observed as significant across the innovation process were activities such as ensuring long term planning (initial phase), ensuring a lead in time prior to implementation (formulation and development phase), and the structural monitoring and assessment of the implications of the innovation (implementation phase). These activities provide the opportunity and time for the project team to understand the nature and implications of the innovation process. It was noted that rooted behind the cultural problems was a lack of understanding by the project team of the implications of using the innovation. Evidence illustrated that by providing a team structurally with the opportunity to be involved in the innovation process, produced a project team that was engaged in the innovation process. For the component innovation type, the provision of access to the decision making process (initial phase) and support workshops (implementation phase) were identified as facilitating this. This reflects the bottom- up nature of the activities of the phase process, as it is the role of the management control system to assist these activities in the role of satisfying the concerns of the project team and the criteria set by the project.

The reflective nature of the significance of the activities and factors of influence defining the nature of the individual phases of the innovation process for each type of innovation, can be assessed further by considering the comparison tables in the appendix (C). Each of the phases is represented, displaying the factors that are common within all three models, those common in two, and those specific to an individual innovation type. It is apparent from such a comparison that although the activities and factors of influence are generic considerations for the management of all innovation processes, the varying nature of the significance levels associated with each type highlights the need to apply these principles reflective of the nature of the context. The assessment of the attribute of type does not change the principles of the research model and its understanding outlined in chapter 6, but enhances the need to view it as a set of recommendations that require to be considered, in addition to being tailored to the nature of the particular context (i.e. attributes) of the innovation process.

7.5 Conclusion

This chapter has identified that the key to achieving effective integration of the innovation process within the project environment, is to understand the nature of the hierarchy of governance determining the management relationship between the two processes. The relationship between these processes was observed to alter depending on the type of innovation, and the nature of this relationship determined the integration requirements of the overall management process. The implications of these differences in integration between the types were evident in the nature and significance of the activities and factors of influence across the individual phases of the innovation process.

Chapter 8

8 Validation of the innovation process model

8.1 Introduction

The methodology chapter highlighted the importance of validating research findings for the completeness of any research. Within the context of model building, when adopting the principles of grounded theory, the process of validation is of greater significance to the overall quality of the research. The process provides the research with two functions, firstly to assess the overall validity of the structural and theoretical assumptions of the model, and secondly to ensure that aspects either missed or overlooked within the model can be incorporated in the final model. It is necessary to look at the validation process as not only an opportunity to validate the research findings, but as a mechanism for improving the model.

Strauss and Corbin (1998) identified that the use of grounded theory for model building requires particular attention to be placed on the validation process. The reliance exclusively on the research sample from which the findings are based presents the problem that aspects of the process may be missed or overlooked. The validation process allows these aspects to be identified and incorporated within the research model, if deemed significant. The literature review highlighted the value of using a multiple analysis approach for modelling the innovation process, as different models draw on different characteristics and aspects. Baskerville and Pries (2001) identified that only by assessing innovation from a number of approaches can a true representation be achieved. This chapter will verify the research model through comparison with four general management innovation models, each representative of the four principle modelling styles for the innovation process. This not only provides verification of the research model but also allows for an evaluation of the impact of the construction project environment on the structure and theoretical nature of the innovation process. This chapter will discuss these implications and suggest improvements to the research model.

8.2 Verification of models using research findings

The four innovation models selected to verify the findings of the research, represent the four most influential styles of representation (as identified by Van de Ven et al, 2000), i.e. 1) the non linear push- pull model (Burgelamn and Sayles (1986)), 2) the linear stage gate model (Cooper (2001)), 3) the emergent journey model (Van de Ven et al (2000)), and 4) the spiral process model (Rosegger (1980)). Baskerville and Pries (2001) argue that it was impossible to represent the complete innovation process from a singular approach of illustration, as individual models provide a representation of the particular theme and research agenda from which the research is focused. As a result when producing a generic model of the innovation process and its management requirements, there is a need to consider and compare alternative methods of representation from other models. This allows for an assessment that can highlight any potential weaknesses or omissions in the proposed research model. Comparison is achieved by superimposing the findings from this research on to the structure and principles of the other models. This process will allow for the verification of the structure of the research model and its theoretical foundations, and provide the opportunity for making improvements.

8.2.1 Burgelamn and Sayles's push- pull pattern model

The push- pull interactive model is classified as primarily a genealogical innovation model (Poole and Van de Ven, 2000) as it focuses on the internal nature of a single innovating organisation. Baskerville and Pries- Heje (2001) argue that this type of innovation model assumes an internal innovation life cycle and captures the instrumental and technological operations of the innovation's diffusion. They define this model as presenting an interactive model of the innovation process. The model represents technological- push as well as that of need- pull, and thus uses both technology- linking and need- linking to realise successful innovation diffusion. The model primarily relates to the interaction between the environment (market) and the organisation, and takes a non- linear form. The organisation has to react to the environment (market or regulation demands) and the innovation process is a fundamental component of this interaction.

Figure 8.1 displays the Burgelamn and Sayles (1986) model illustrating the elements of the need- pull pattern and the technology- push pattern. The foundations of the push-pull model are geared towards the organisational context of product development, however the structure and principles of the model can be adopted to any context, as all innovation can be viewed as experiencing a pull and/ or a push in order to drive it into being. Figure 8.2 (a/b) displays an adaptation of the push- pull model from the research findings, and reflecting the context of the construction project. The imposing of activities and factors of influence from the research into the structure of the Burgelamn and Sayles (1986) model highlights the universal ability of the model to reflect the push- pull patterns of innovation within any context in this form. When comparing this

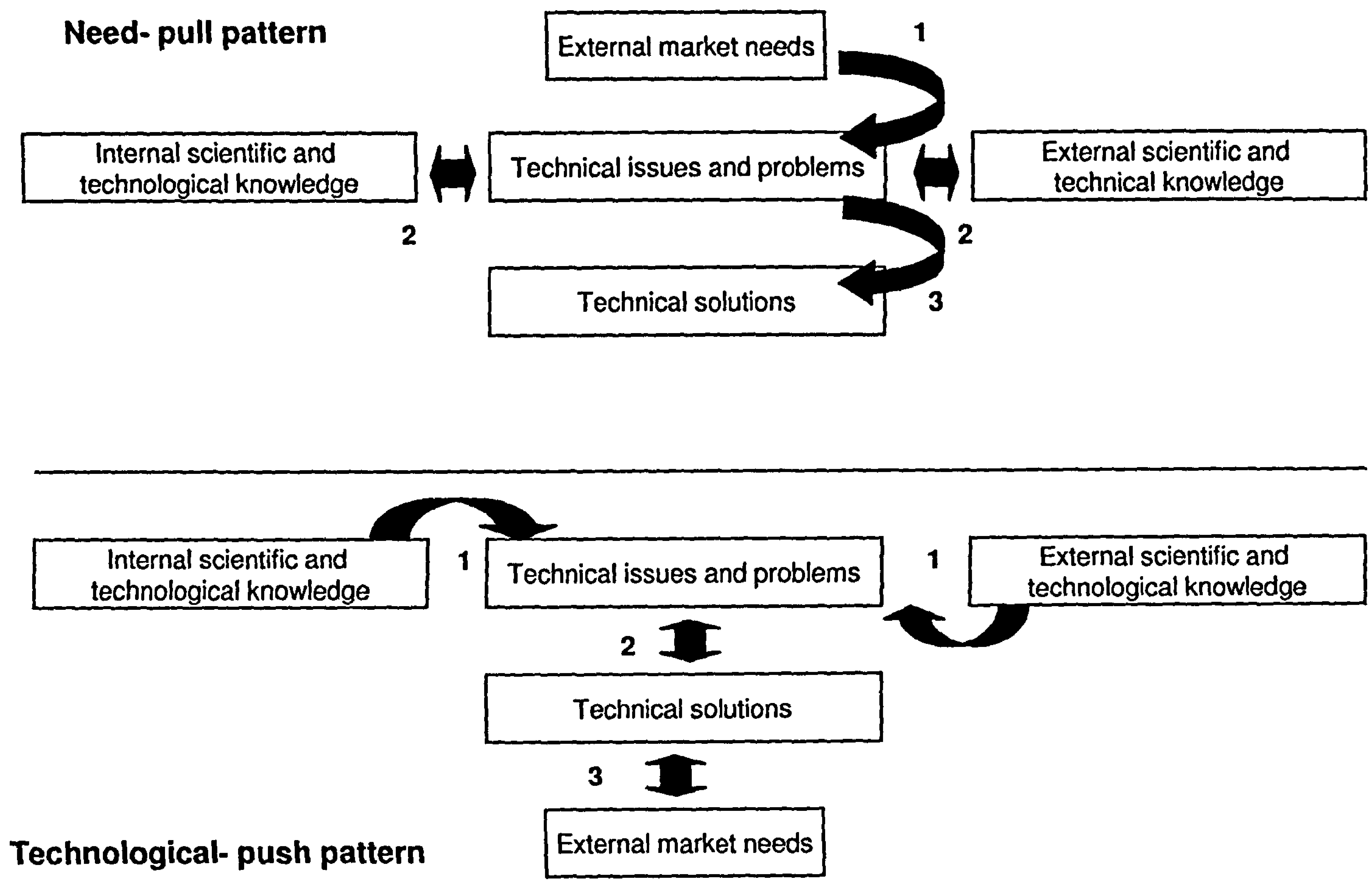


Figure 8.1 Burgelman and Sayles- Push pull model (1986)

(Cited in Baskerville and Pries- Heje (2001))

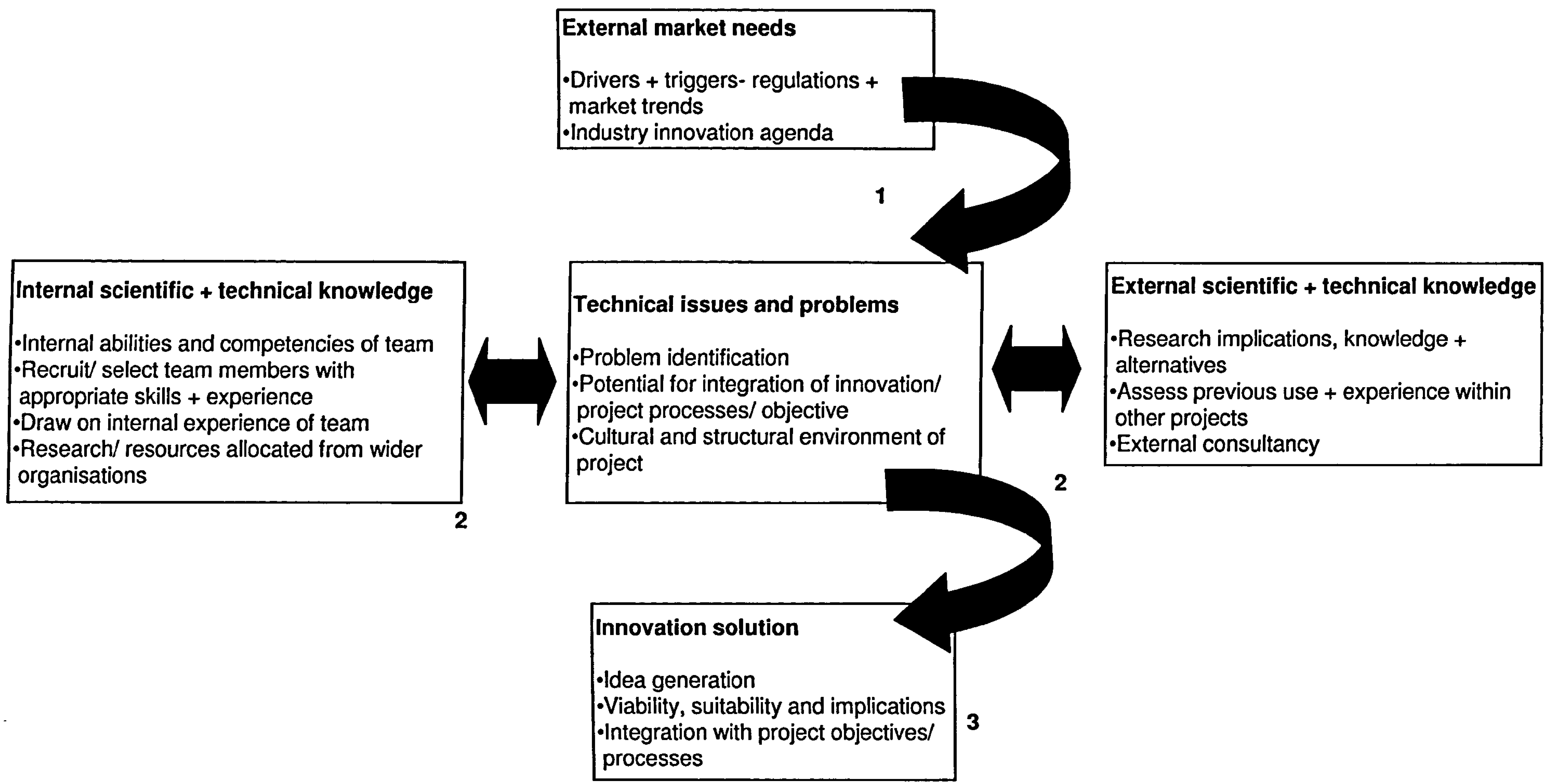


Figure 8.2 a: Adapted version of Burgelamn and Sayles (1986) need- pull pattern from research findings

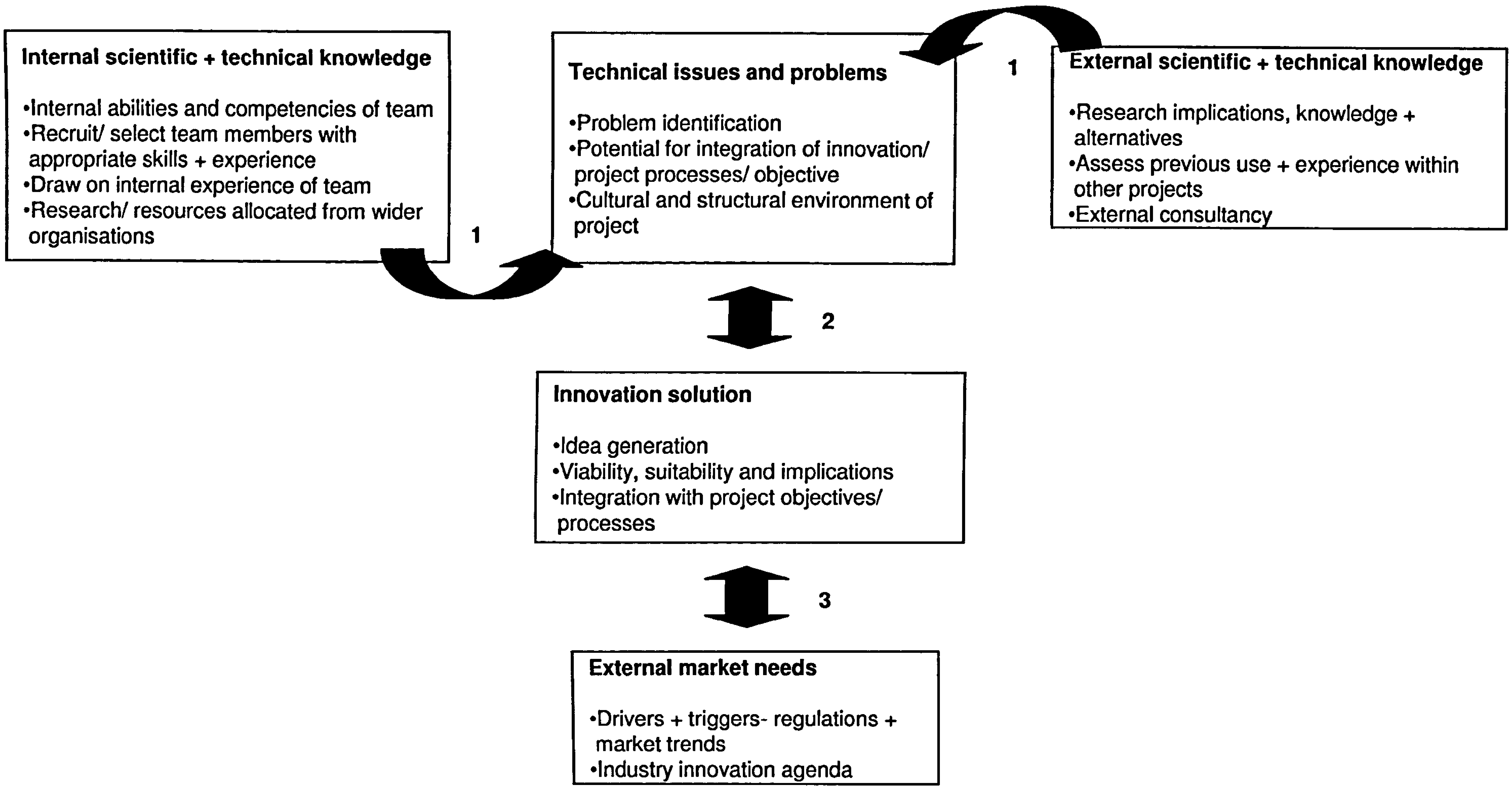


Figure 8.2 b: Adapted version of Burgelamn and Sayles (1986) technology- push pattern from research findings

means of representation with that of the research model (figure 6.1), it is possible to make a number of observations.

Displaying the research findings using the push- pull model, allows a degree of focus to be achieved on whether the innovation process was either reactive or proactive in nature. The driving force behind an innovation's idea creation plays a significant role in the composition and nature of the innovation process that follows, and the overall requirements of the management interaction. The linear nature of the research model has difficulty in the visual representation of this concept, as there is a wide range of factors of influence behind the idea generation process and it is difficult to represent them visually within a phased model. The pull- push model is useful for allowing the representation of this process in detail within a non-linear format and thus exposes dynamics not possible within a structural representation of a linear phased process model.

Examination of the push- pull model in figure 8.2 (a/b) reveals that the activities and influencing factors identified in the research are represented in the initial phase of the research model. However, where the research model is limited through the nature of its representation to identifying the activities and factors of influence, the push- pull model allows for the visual representation of the needs and desires behind the use of the innovation. Francis's (2000) model of the innovation process similarly includes an idea acquisition phase that represents such activities; however, difficulty was also noted in reflecting the proactive or reactive nature of the innovation. Process models find difficulty in visually representing these dynamics, as they are focused on the entire innovation process, and not solely the specifics of these issues. The benefits of using a non- linear model, such as the push- pull, allow for a better understanding of a specific issue to be developed, in isolation to the remainder of the process. The comparison between the push- pull and the research model, however, identified that each model has their specific purpose for representation, and that one should not replace the other, but that they should be considered as complementary.

Whilst the push- pull model is useful for exploring the dynamics of the initial phase of the innovation, it is possible to evaluate this within the research model by understanding the initial phase. The considerations displayed within the push- pull model are key to the phase process, the factors of influence and management requirements within the initial phase of the research model. Examination reveals a range of both push and pull considerations that require to be observed by those managing it and a need to be reactive to the specific needs that they present. The context of an idea's generation within the construction project predominantly emanates from influences such as problem solving activities (pull), and regulation changes (push). However, the research revealed that within the project environment ideas will often emerge due to a combination of the two. The push- pull model does not possess the sophistication to represent this.

It is suggested that alterations are not required to the research model, as the principles of the push- pull model are contained within it. The push- pull model can be used to provide a simple non- linear representation of the basis from which the innovation process is developed within the construction environment. This places emphasis on the need to understand the manner to which an innovation appears within a project and identifies this as affecting the manner of its management through the remainder of the process. However, it is important to view this as a tool to use in conjunction with the linear based research model and not as a replacement for it.

8.2.2 Cooper's stage gate model

Cooper's (2001) stage gate model represents innovation as a process existing as a series of stages separated by decision gates that require to be passed in order for the process to proceed. Under Van de Ven et al's (2000) criteria, Cooper's model would be identified as a functional model, due to the setting of goals for completion. The context of this model focused within that of the organisation and the process of product development. Figure 8.3 illustrates the stage gate model produced by Cooper outlining the 5 stage (decision) gates and resultant phases of the process. An adaptation of Cooper's (2001) model was produced in figure 8.4 from the findings of the research, and reflected the context of the construction project. By following the principles of Cooper's model, it was possible to produce a model reflective in structure. However, it was necessary to adjust the nature of the stages and decision gates to reflect the contextual distinction between the product development environment of Cooper's model, and that of the construction project environment.

An example of the difference in the context between the models is illustrated by Cooper's (2001) display in figure 8.3 of the completion of the innovation process as a production and launch stage, representing the point of passing the innovation from the process to the organisation and its wider strategies. The lack of an implementation stage is common within models of product innovation processes, as the processes tend predominantly to be centred on the innovation's development prior to launch. Within the context of manufacturing product innovation, this approach is representative of the

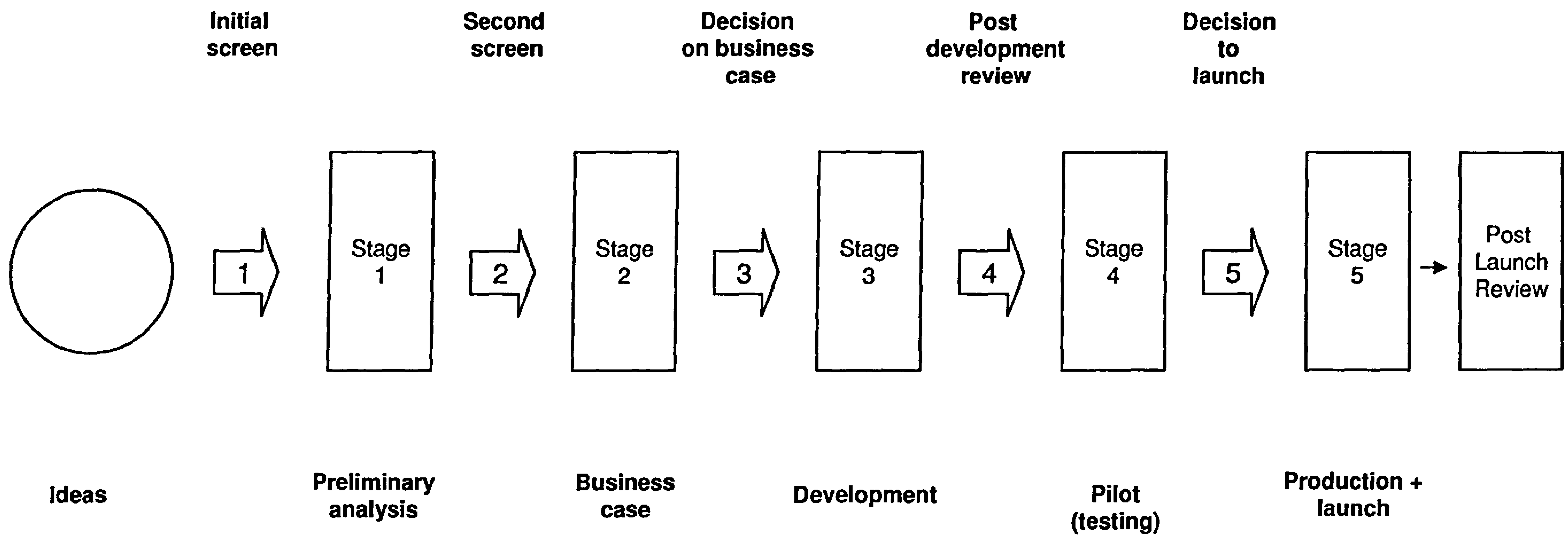


Figure 8.3: Cooper's (2001) stage gate product development model

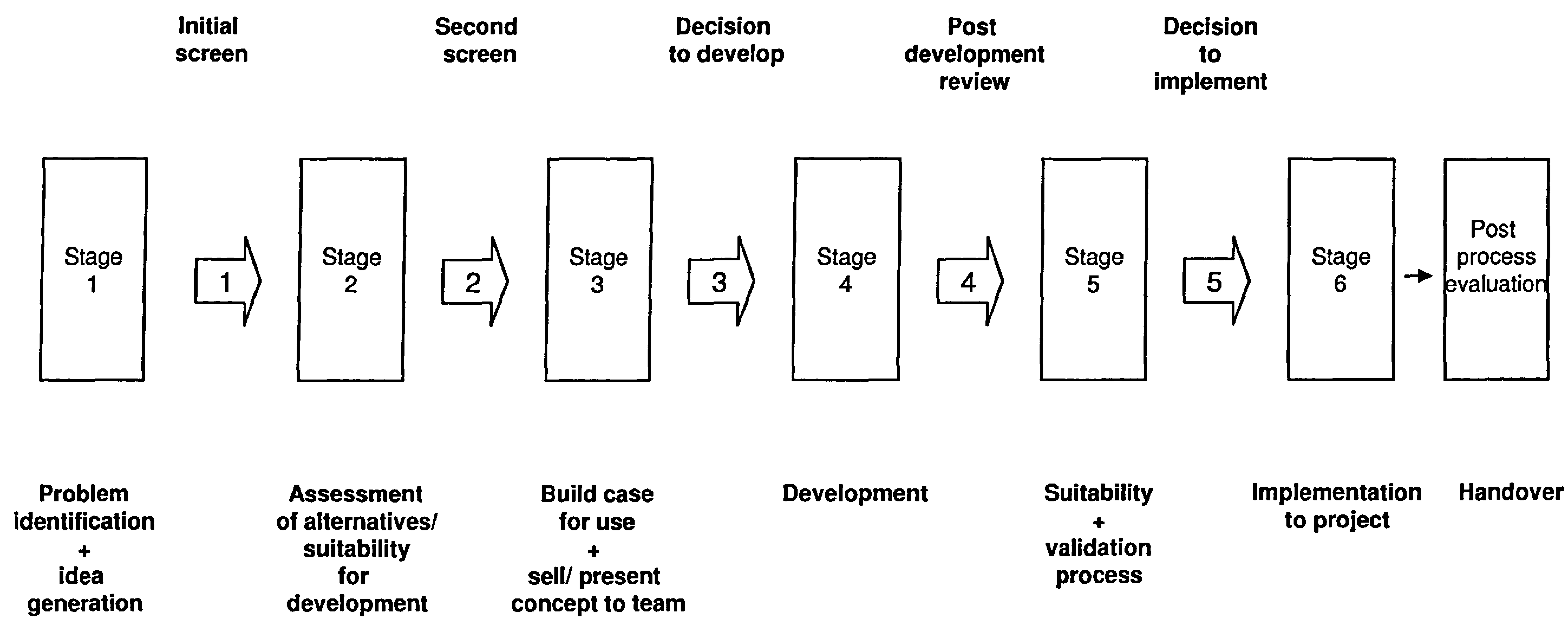


Figure 8.4: Adapted version of Cooper's (2001) stage gate model from research findings

fact that by the time the innovation reaches the production and launch stage the process in theory should have reduced the level of uncertainty and risk to a negligible level. Under Cooper's principles, by the time the process reaches the production and launch stage, there should be no doubt in the technical side of the innovation, as it will be deemed by management to satisfy the criteria laid out for its specification. This leaves management consideration to the needs of innovation's application to the market and organisational product processes. Figure 8.3 therefore places greater significance on testing the innovation for its quality or performance, thus ensuring a successful launch to market. By contrast, the construction focused model displayed in figure 8.4, places greater significance on assessing the suitability of the innovation within the process (assessment of alternatives/ suitability for development, and suitability and validation stages). Within the construction project there is little room to test the innovation in practice prior to its application, due to the unique nature of the project environment. Consequently, whilst the development stage of the process attempts to plan and reduce the risk of the innovation's implementation to a sufficient level, there remains the need to carefully manage and control the innovations application during construction. Therefore, the differing context's of the innovation process environment between the two models is reflected in the differing nature and composition of the stages.

Cooper (2001) argues that the use of the stage gate model is not a substitute for sound project management methods, and advocates for the stages of the model to demonstrate the application of project management principles. Examination of each phase of the research model shows that it contains a series of project management methods geared towards the task of ensuring that the phases fulfil their objectives. The need to achieve the authority to pass from stage to stage is common within both the research model and the stage gate model, and consequently the activities of the individual stages/ phases are dominated with achieving the satisfaction of the requirements of the gates. Comparing the models reveals that the principle and function of each gate are essentially the same, although the wording and nature of the decision is adjusted to reflect the context in question. An example is provided in Cooper's (2001) model, where the fifth stage gate is titled decision to launch, which is inappropriate for the context of the construction project, but instead is replaced by the decision to implement. The research model ties strongly to these principles in its structural form and at a conceptual level.

Within Cooper's recent work (2001) he acknowledges and investigates the potential existence of fuzzy stages within the process. His initial work assessed the innovation process as a structured sequential process; however, his recent acknowledgement of the need for fluidity within the process, corresponds with the observations made within the research model. Construction projects require an innovation process that is significantly less structured and rigid than Cooper's 5-stage model. His acknowledgment that stages and their activities can exist in a fuzzy manner; allows for the principles of Cooper to be applied to the construction context and adapted using the findings of the research in the manner of figure 8.4.

A comparison of the stage gate and the research model revealed a difference in the number of decision gates, with Cooper identifying 5 and the research model identifying 3. However, Cooper's (2001) acknowledgement of the fluidity within the process led to the development of a fast track model where his 5- stage model was reduced through the merger of some of the stages. Within this model, Cooper merges the preliminary analysis and business case stages into one, and the development and pilot (testing) stages are merged as to form one stage also. The identification by Cooper (2001) that the stages of the process can be merged depending on the level of risk of the project, contradicts his earlier work where the process was rigidly displayed as having 5 phases. Cooper identifies a 3-stage model, displayed in figure 8.5, and although sharing many similarities with the research model in its structure, retains the reflection of a product development process in context. Figure 8.6 represents the interpretation of Cooper's 3-stage model applied to the context of the research findings, combining the problem identification and idea generation stages, the scoping and building case for use/ selling and presentation stages, and the development and suitability/ validation process stages. These three stages then feed into an implementation stage, prior to a handover/ post evaluation stage. The structure of the 3- stage version of the model displays many commonalities with the model developed within this research.

The 3-stage adaptation of Cooper's (2001) model (figure 8.6) provides a useful focus for the comparison of the principles of Cooper's model against those of the research model. Although they are similar, they demonstrate differences that require to be considered for aiding the development of the research model. The first two stages of figure 8.6 shares many commonalities with the initial phase of the research model. The initial phase in the research model displays a singular phase to represent what the 3-stage model displays in two. Consideration of the analysis within this research provides the evidence to suggest that the initial phase within the research model represents a more realistic view of the inception of the idea and subsequent initial development activities when displayed within a singular phase. Using Cooper's principles applied to construction produces an unrepresentative decision gate between the idea generation and the initial activities for securing the initial authority for progression. This decision

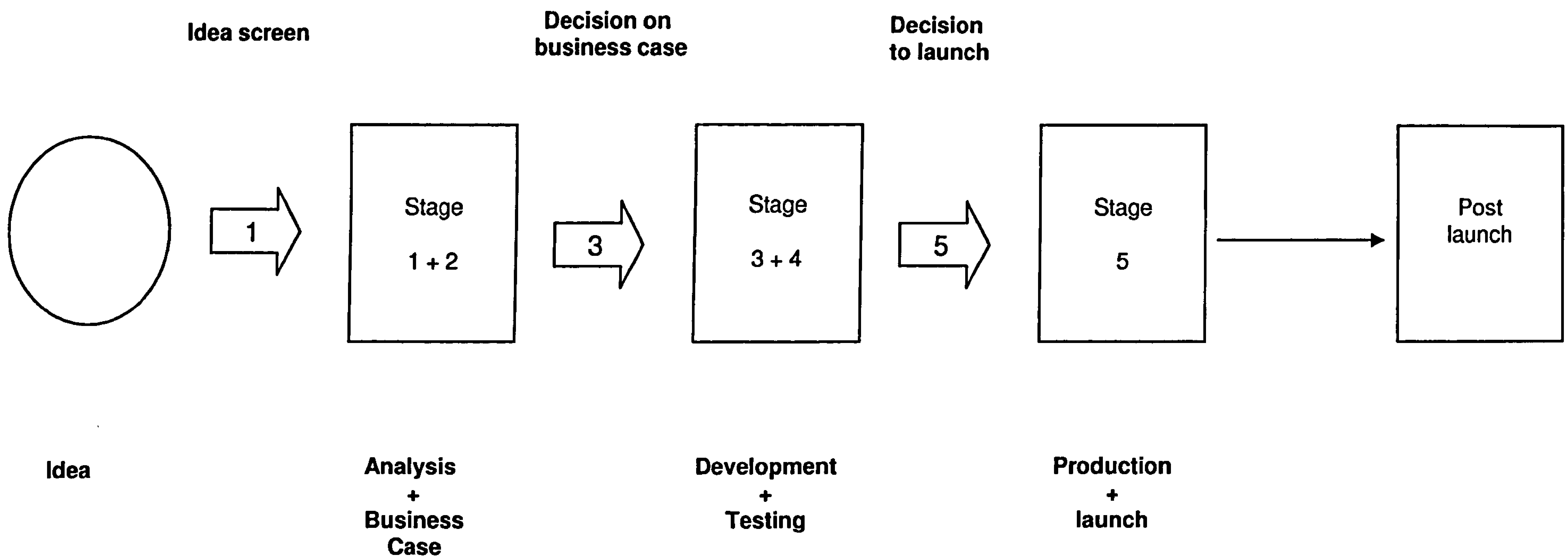


Figure 8.5: Cooper (2001) fast track stage gate model

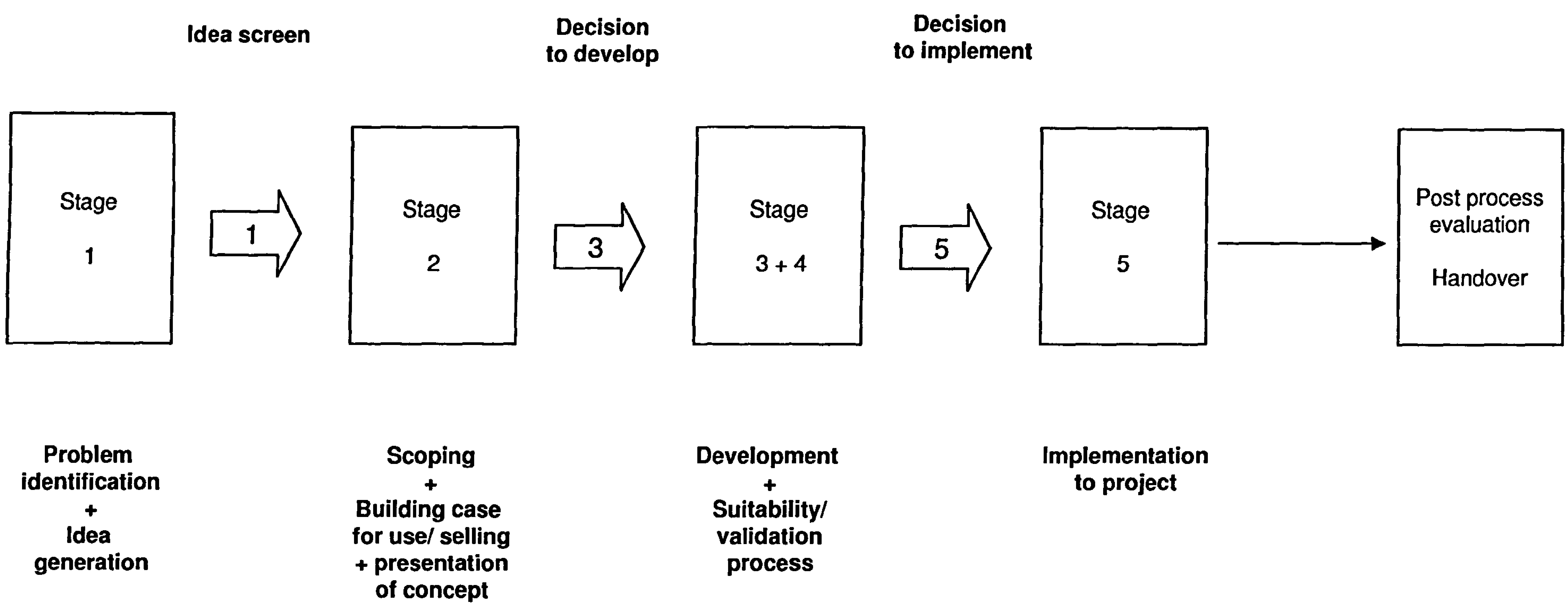


Figure 8.6: Adapted version of Cooper's (2001) fast track stage gate model from research findings

gate was not observed to be of such significance within the case studies that it would require representation within the innovation process, and thus is not illustrated in the research model. The initial phase of the research model allows greater flexibility by not including this additional decision gate, thus providing for it to reflect more of the fuzzy nature of the activities of this phase. Cooper's positioning of this decision gate is suitable within the context of product development, however, it is difficult within the context of the construction project to group these activities as operating within separate phases, as it is necessary to assess constantly the validity and alternatives simultaneously.

Contrasting the adapted construction version of Cooper's (2001) 3- stage model and the research model, highlights the similarities between the formulation and development phase of the research model and the development + suitability/ validation stage of the adapted version. The similarity between the representations emerges when considering the decision gates that form the boundaries defining the nature and function of the phase/ stage. In both, the phase/ stage begins with a decision taken by management to accept the concept or philosophy of the innovation and to resource its development. From this point, the activities of the phase/ stage are geared to gaining the permission of the decision makers to implement the innovation in practice.

As described earlier, the context of the construction project deems that Cooper's (2001) display of the stage as a development and testing stage, with the function of developing a product from a concept and preparing it for market, is not appropriate for the construction context. When the principles of this stage are applied to the context of the research findings, they adapt and are displayed as the development + suitability/

validation stage, focusing on the development of the concept into a practical proposition for implementation. These are the same principles as the development and formulation phase of the research model outlined in chapter 6. Assessment of figure 8.6, reveals that the distinctions between Cooper's principles devised within a product development context (figure 8.5), differ during this phase due to the context of the environment, as opposed to distinctions in the principles behind the models.

Within the adapted version of the 3- stage model (figure 8.6), the principles of Cooper's production and launch stage (in figure 8.5) were altered to reflect the context of the construction project through the identification of the implementation phase. The role of Cooper's production and launch stage is to provide the platform for the effective launch of the product into the market and effectively handover the innovation to the organisation's wider product management operations. The display of the implementation stage within the adapted version of the model, reflects the activities of implementing the innovation in practice within the project. Comparison revealed that the implementation of an innovation within the construction project required many of the same management controls as displayed within Cooper's launch stage. The nature of the decision gate at the beginning of the phase shares the same principles, only reflecting the particular context in question. For example, in Cooper's model the decision to begin the production and launch stage is reached by being satisfied that the concept is developed and tested to an acceptable standard for market. On the other hand, in the adapted version of the model, the decision to begin the implementation stage is reached by being satisfied that the concept is developed and suitable for the standards and requirements for implementation into the project. Although the production and launch or implementation of the innovation takes place within different contexts and environments, the principles behind the activities of each stage are similar. The research model contains an implementation phase operating under the same principles as those within the adapted version of Cooper's model.

The main difference between the adopted version of Cooper's principles in figure 8.6 and those of the research model (figure 6.1), relates to the relationship between the implementation phase/ stage and that of the handover/ post process evaluation phase/ stage. These phases/ stages are identified in both representations, however within the research model the implementation phase requires to be completed prior to its handover phase commencing. A decision gate represents this, as evidence showed that a decision was required to signal the completion of implementation, prior to the process of handover and evaluation. Analysis revealed that within construction the separation of the two phases was marked, due to the physical nature of a construction project. This contrasts with Cooper's model, which illustrates this transition between the stages through an arrow reflecting a fuzzy process of transition. This contrast reflects the distinction between the product development and construction project contexts.

The launch of the product to market within Cooper's model represents a process where the innovation is handed over to the organisation for distribution and marketing. As a result, the handover and post evaluation can take place at any point following the launch of the product, and continue throughout the product's lifecycle following the decision to launch. The adapted version of Cooper's model reflects this within the context of the construction project. However, this fails to represent the need for separation between the implementation and the handover as displayed in the research model. The fuzzy nature of the transition between the stages under Cooper's principles, fails to acknowledge the need within construction to separate these activities.

A comparison of the adapted version of Cooper's model and the research model reveals a contrast in the inclusion of the post- evaluation process. Under Cooper's principles this is included as part of the same stage as the handover. Although adapted to reflect the construction context, the inclusion of these processes in the same stage reflects a fuzzy relationship between this stage and the implementation stage. These principles, although they are appropriate for product development, fail to reflect the reality of the construction context. The research model identified the handover phase as a separate phase separated by a decision gate from the implementation phase. It represented the structured process of reviewing the performance of the innovation, and handing over the completed innovation to another party. The research observed that this was distinct from the unstructured post- evaluation process, which assessed the performance of the innovation post (innovation and project) process. Product development models do not display the same structured separation of these processes, and thus can group them together due to their fuzzy appearance.

A significant distinction between models is represented by the absence of an overall innovation management phase from Cooper's models. This was observed to be a fundamental component of the research model, providing both the management of the overall direction of the process, and feedback between the needs of the individual phases and overall process. The integration of the innovation process with that of the project process was also identified to be conducted through the overall innovation management. Cooper's failure to represent this within his model reflects the product development context of the process, and his identification that the innovation process should exist in parallel with the principles of project management. However, within the context of construction, the significance of effectively integrating the needs of the innovation process with those of the project process, merit the need to represent the overall innovation management of the process. In addition, the increased influence of feedback between the phases of the process within the construction context needs to be represented within the process. This is achieved through the constant interaction between the overall innovation management and the individual phases of the innovation process. The need to achieve this representation within the product development model is not as necessary; due to it is predominantly standalone nature within the context of an organisation (Cooper, 2001).

It is clear that Cooper's stage gate model for product development, when applied to the context of the construction project, shares many similarities as a process with the research model developed in chapter 6. The structural composition of the model with decision gates and defined phases represents significant similarities in the flow of the processes. The contrasts between many aspects of the models were highlighted within this section to reflect the contextual nature of the environment within which they were developed, however a major structural distinction was noted in the inclusion of the overall innovation management for the innovation process within the research model and not in the stage- gate model.

Cooper's visual representation of the function of each decision gate within the model, by displaying its title above it (i.e. idea screen) was noted to be more effective than the use of numbers for representation within the research model. The research model favoured to outline the function of each decision gate within the body of the descriptive text in chapter 6. However, the instant understanding that is established visually from Cooper's representation highlights a need to reflect the function of each decision gate visually within the research model.

8.2.3 Van de Ven et al's innovation journey model

The emergent approach is the third style of representing the modelling of innovation. Baskerville and Pries- Heje (2001) argue that this approach moves away from the interactive (push- pull model) and functional (stage gate model) approaches by presenting a method of thinking relating to innovation process that shows innovation as a flowing process, evolving within differing temporal periods and spatial occupation. They identify Van de Ven et al's (2000) innovation journey model as an influential example of the emergent approach. Van de Ven et al (2000) criticised the use of interactive and functional models for their restrictive nature and tendency to prescribe the nature of the process onto the innovation. They argued strongly that a prescriptive approach to innovation might stifle the innovation's evolution and prove unsuitable as a representation of the reality. Baskerville and Pries- Heje (2001) argued that 'the innovation diffusion within the emergent model is an unstructured and emergent phenomenon that is too multivariate and convoluted for modelling in steps or stages. Like social culture, innovation evolves as a mixture of old and new ideas, directions and stakeholder. Moreover, research into innovation is complicated because the stories change over time.' The empirical focus of Van de Ven et al's model is tied in its focus to the context of product development within the organisational situation of manufacturing and is illustrated in figure 8.7.

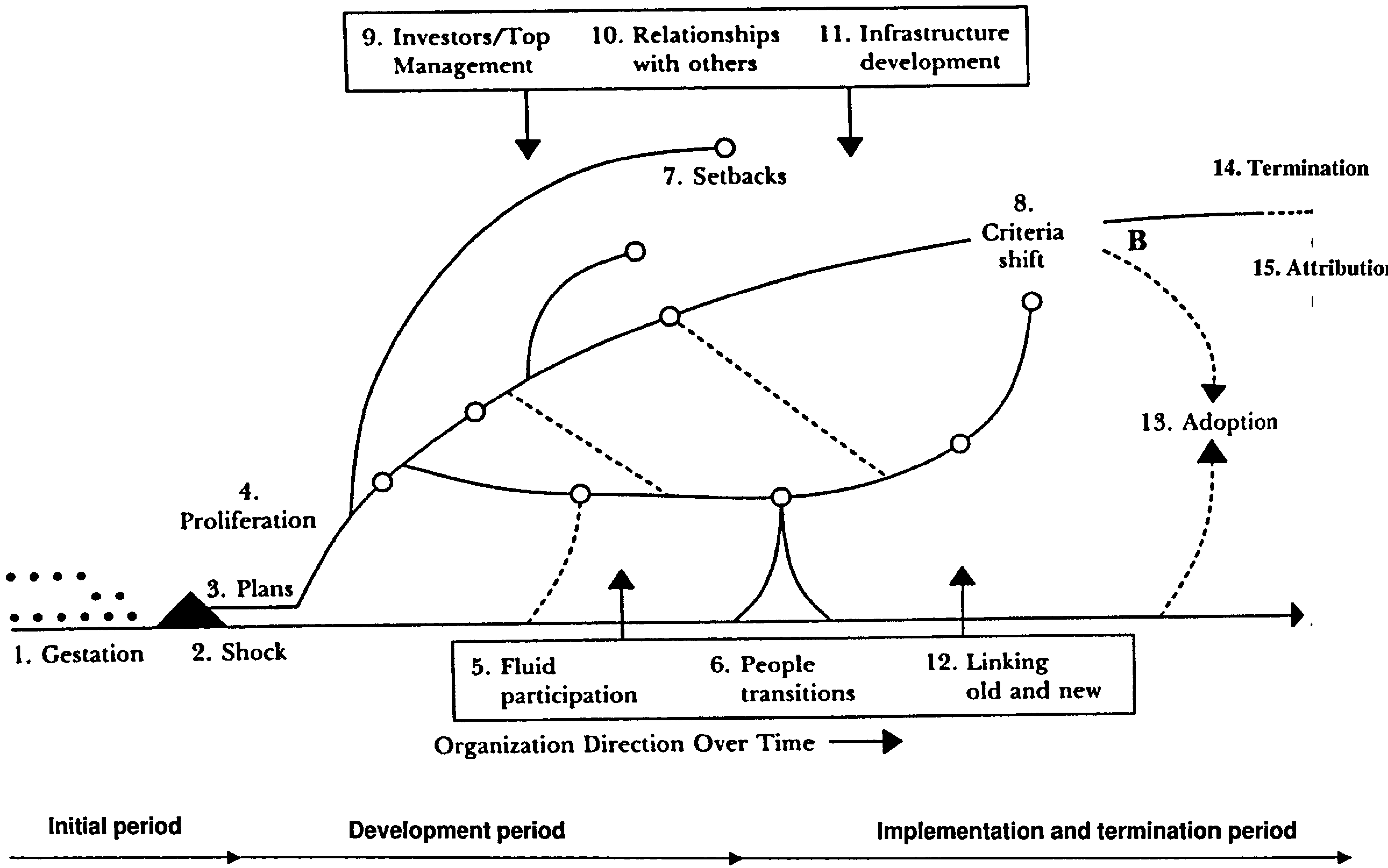


Figure 8.7: Van de Ven et al (2000) innovation journey model

The principles of Van de Ven et al's (2000) innovation journey model attempt to present an overall composition map of the key processes commonly observed during the tracking of an innovation. The model is divided as a journey into three innovation periods where the processes of crucial tasks and challenges differ systematically across each (Van de Ven et al, 2000). These three periods are the initial, development and implementation + termination periods. Figure 8.7 illustrates the emerging nature of the innovation process as it traces and maps the process during its lifespan. The model displays arrows illustrating the key management considerations and influencing factors affecting the innovation process at various points. Van de Ven et al (2000) saw management's role to be reactive to the needs of the innovation process, as opposed to the rigidity of the sequence of management intervention followed within functional models such as Cooper (2001). Van de Ven et al argue that Cooper's use of decision gates fails to reflect the fuzzy and fluid nature of the process. They prefer to offer management recommendations that should be considered if appropriate to the situation, as opposed to a series of requirements for observation. The principles of the innovation journey model aim to move away from the control and sequence that governs the interactive and functional models for innovation, and in essence to display an evolving process.

Adapting the principles of Van de Ven et al's (2000) model to the context of this research provided evidence of the responsive nature of the model to the context in question. The periods of activity identified within the original model (figure 8.7), are principally constant with those observed in the adapted model, shown in figure 8.8, although they are adapted to reflect the given contexts of focus. It is possible to identify activities such as shock/ trigger, gestation, and planning/ funding within both models as

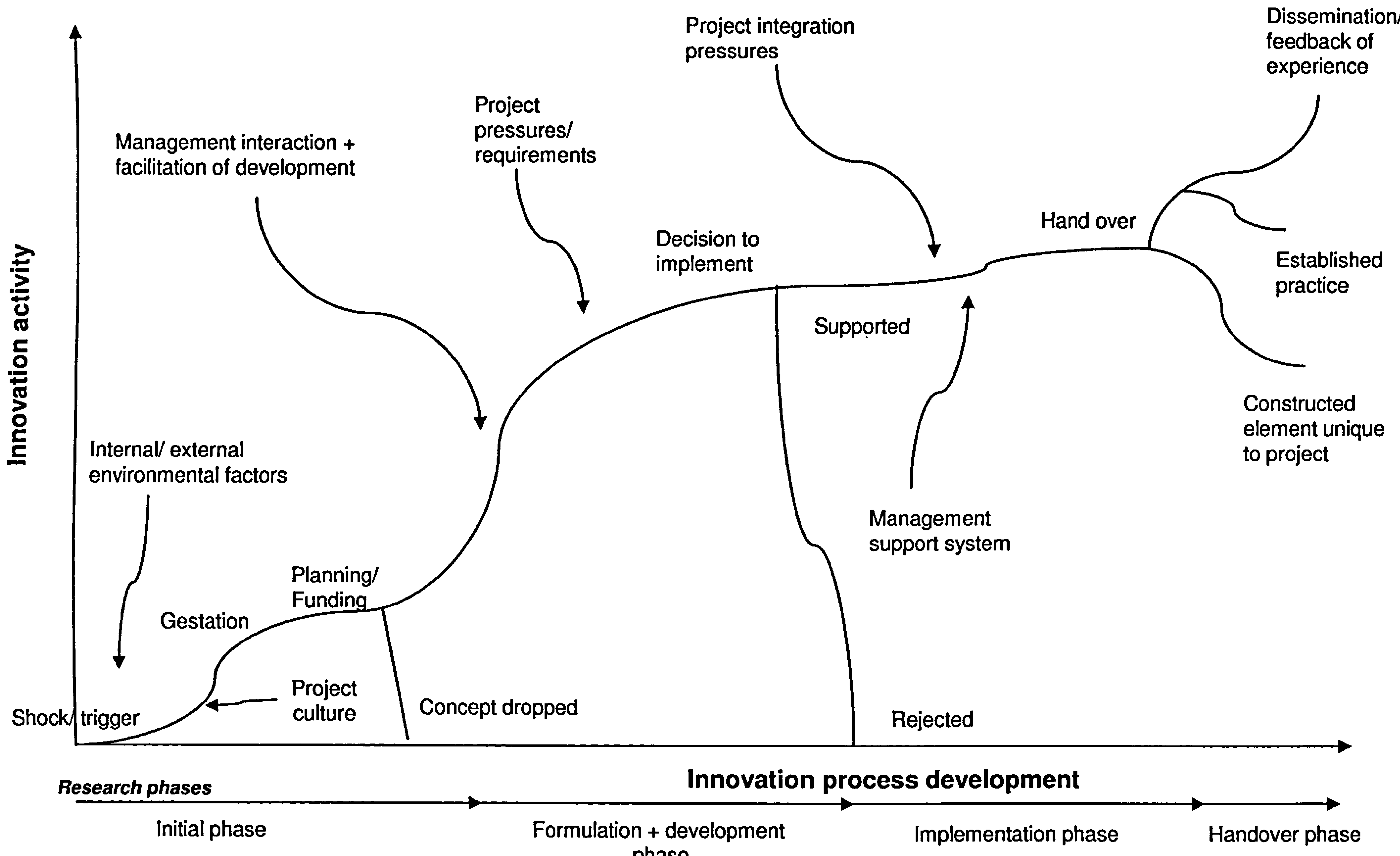


Figure 8.8: Adapted from Van de Ven (2000) innovation journey model from research findings

representing the initial period of the innovation process. The nature of these activities reflects the emerging nature of the innovation and the evolution of the concept within both product development, as well as within a construction project. The activities of the development period within both contexts shares similarities, as the concept moves from a philosophy through its development to a point where it is ready for implementation. During both of these periods the two models require interaction with the environment in which they exist. The adapted model identifies the influence from the project culture, and the pressures and requirements of the project environment. Van de Ven et al's (2000) model requires interaction with that of the organisation, ensuring that the innovation evolves in line with its overall strategic direction. The models' illustrate at the end of each of these periods a point where the concept is continued or dropped.

Van de Ven et al (2000) observed the final period of the innovation process as the implementation + termination period. Due to the nature of the construction project, there is a need to adapt this period and to create two periods i.e. the implementation and the handover period. Van de Ven et al's focus on product development determines that the implementation of the innovation is tied in with the activities of termination for the innovation process, as this represents the products launch into the market and the hand over of its management to the wider strategies of the organisation. Within construction there is a need to separate these activities into two periods, and the nature of the implementation of the innovation within a construction project, due to the physical nature and lifespan of this activity. The handover phase represents the point of post process evaluation following the completion of the implementation period. Adapting the considerations for management during termination within figure 8.7 to the context of construction in figure 8.8, provides three contrasting paths for the innovation dissemination/ feedback of experience, established practice, and constructed element unique to project.

Van de Ven et al (2000) placed considerable emphasis on the applicability of the principles of the innovation journey model to other environmental contexts. The innovation journey model aims to provide a high-level understanding of the emerging nature of the innovation process, however closer examination reveals elements of many of the aspects of the functional models, highlighted particularly by the use of the decision points. However, Van de Ven et al (2000) were conscious not to describe these to be gates in the structural manner of Cooper (2001), and preferred to view them as an evolving part of the process, representing a consideration for recommendation as opposed to requirement.

Comparison of the principles of the innovation journey model with the research model outlined in chapter 6 reveals many similarities, and that the activities identified were effectively the same. The description of sets of activities within each phase as appearing in a fluid and fuzzy manner is reflected in Van de Ven et al's principles (2000) through the focus on the emerging nature of the process. The management intervention within each phase shown within the adapted version, differed with the research model through its representation of a management control system. Van de Ven's et al (2000) emphasis on the responsive nature of the management within each period of the process is retained in the research model, as each activity of the management control system varies in its significance in response to the nature of the factors of influence. Both models, although contrasting visually, share the principle of following a fluid/ fuzzy process within each phase, responsive to the context in hand.

However, it is apparent that Van de Ven et al's (2000) description of each phase focuses more on recommendations for management as opposed to the requirements for consideration within the research model. Their description focuses on recommended activities, whereas the research model places emphasis on outlining the entire management system for each phase.

The use of decision gates within the research model at a structural level align this model with that of the functional models such as that of Cooper (2001). Whilst the research model acknowledges the need to reflect the fuzzy and fluid nature of the process advocated within the reactive nature of Van de Ven et al's model, there is a need to reflect an element of management structure to the innovation process that represents the nature of managing innovation within the construction project. The adaptation of Van de Ven et al's (2000) emergent process fails to acknowledge that within construction projects the pressure of time restricts the ability of the concept to emerge within its own timeframe without careful management control and direction. The construction project has a specific timeframe within which the innovation process operates, which reduces the ability of management to be purely reactive to the innovation under Van de Ven et al's logic. The use of decision gates within the research model reflects the need by management to control the progress of the innovation process in line with the considerations of the project. An example of this is provided when considering technological innovations, where the decision gates of the innovation process are fixed to the timing of the decision gates of the project process. The research model reflects the need for a functional approach to ensure the innovation progresses in line with the requirements of the project, whilst retaining the fuzzy and fluid nature of the individual phases.

The absence of the influence and control of the overall innovation management of the innovation process, in the adapted representation of the principles of Van de Ven et al's (2000), marks a significant contrast with the research model. The research model identified that not only did each phase experience management specific to the needs and influences of that phase, but required to represent the overall innovation management of the innovation process. As the Van de Ven et al's model represents the level of innovation activity, and the nature of the management response and influencing factors to the activities of the process, such structural considerations are not included. This fails in the case of the adapted model, to reflect the need to manage the innovation process on different levels, and does not represent the need for management to observe, monitor and adjust the individual phases of the process to reflect the direction and requirements of the innovation process as a whole. The representation of this structured approach to management could be argued to be functional in its appearance, but as explained in chapter 7 it remains responsive in its function to the needs of the process. The product development context of Van de Ven et al's principles allow, to a greater extent, for a process that evolves in its own timeframe rather than within the construction project context. As a result, the need to represent such management interaction is not as pressing as within the construction context, due to the procedural nature and time/ cost orientation of the project environment.

The difference of the style of the representation between the research model and that of Van de Ven et al (2000) provides reasoning for the need to include the overall management process within the research model. The innovation journey model represents the level of innovation activity at a given point across the life of the innovation process. Although highlighting the intervention of management within the process, it does not display the management of the process. The representation of management response, as opposed to the management system, does not require to display elements such as management control at the different levels, or pathways of feedback. Van de Ven et al acknowledges this within the description of the model, but highlights the need to adopt a multiple modelling approach to understanding innovation. This was the approach advocated by Baskerville and Pries- Heje (2001), outlining that different models highlight different aspects of the innovation process. Van de Ven et al shares many similarities in its description of the innovation process with the research model; however, the focus on innovation activity fails to establish an understanding of the management system that is achieved in the research model. The context of the construction project environment determines that an understanding of the level of innovation activity is not of such great importance, as to that of the product development context. As a result, the research model, due to its focus on the management of the innovation process, does not require to adjust to reflect this aspect. Van de Ven's et al (2000) model should be considered to inform the observations of the research model, and within this research it has been possible to validate many aspects of the process.

8.2.4 Rosegger's innovation process model

The fourth style of representation for modelling the innovation process considered within this chapter is through its display as a spiral. Baskerville and Pries- Heje (2001) failed to identify the display of the innovation process as a spiral in their critique of the interactive; functional, and emergent styles of modelling innovation. Within general management, concern was expressed by the likes of West (1990) who argued that these styles of modelling failed to effectively represent the levels of feedback existing between each of the phases of the process. Jones and Saad (2003) identified the lack of feedback contained within many of the innovation models produced for construction, as traditionally they are based on the functional and emergent styles. They proposed the use of Rosegger's (1980) innovation process model, as a method for effectively representing the processes of feedback between the phases of the innovation process. Rosegger's (1980) representation of the innovation process as a spiral was an attempt to improve the understanding of the feedback between the phases, through the recognition of the ability to improve the process by gaining of experience from one phase to the next.

Figure 8.9 displays Rosegger's (1980) representation of the innovation process, and illustrates the enhancement of the flow between the individual phases. Rosegger (1980) criticised linear models (i.e. Cooper (2001) and Van de Ven et al (2000)) for not taking into account the numerous and complicated feed- back mechanisms influencing the process of innovation. Jones and Saad (2003) described the model 'as not based on stages, but on a multi- cycle search for information in which decision- makers can return a new idea to a previous cycle, terminate it at any level of development, speed it up or slow it down depending on the existing circumstances.' The key identification made by Jones and Saad (2003) was the ability to modify the idea in response to feedback on changes from both the internal and external environment. The model represents a series of proposals, requiring a decision of approval in order for the proposals to become activities of action. Figure 8.9 illustrates the process emerging as an idea, which is formulised into a proposal. The line represents the point of decision where it transfers into action. Failure to achieve permission for the progression of the

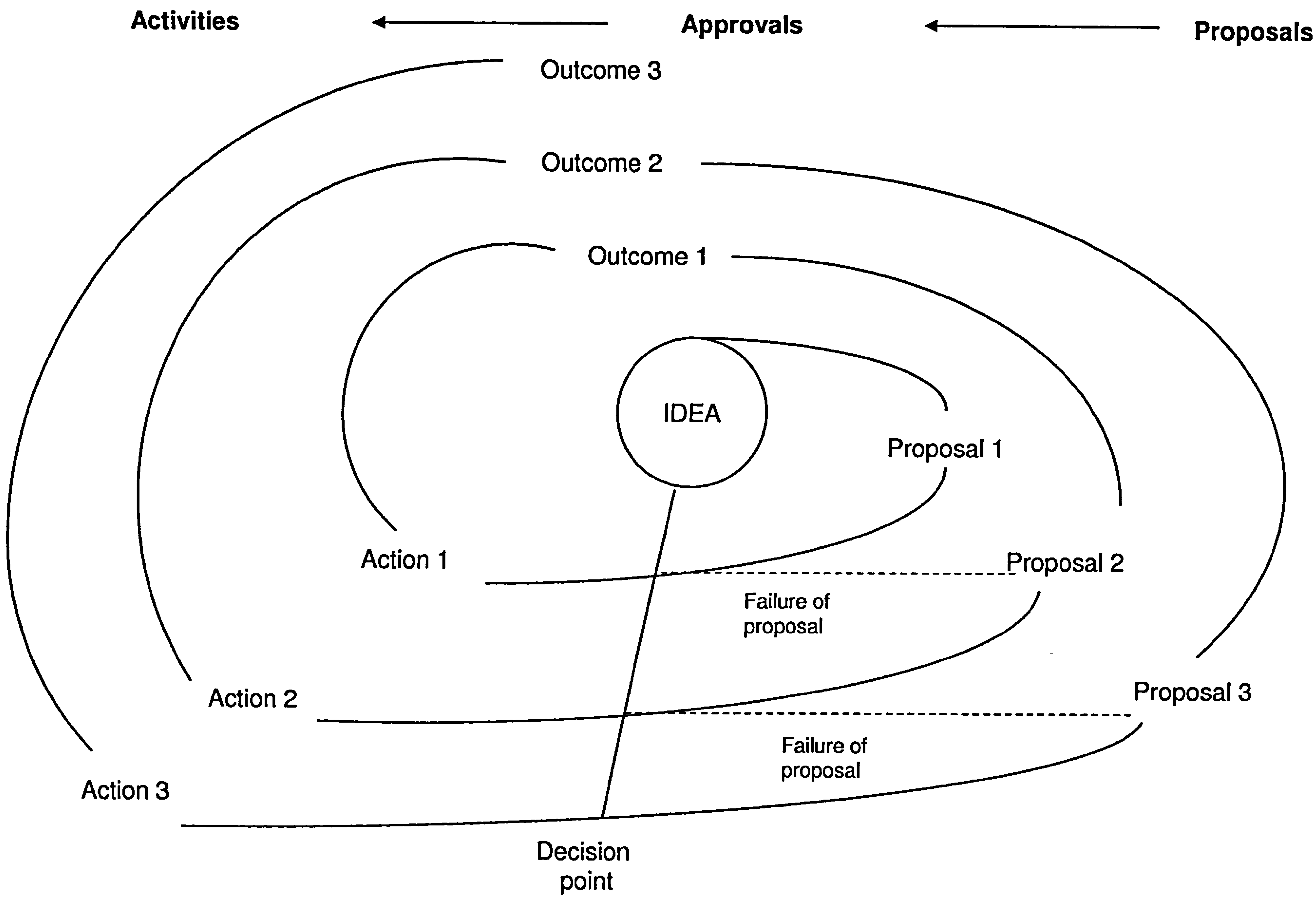


Figure 8.9: Rosegger's (1980) model of innovation

proposal at the decision point results in the modification of the proposal through feedback. This process continues until completion, indicated at outcome three (although the number of outcomes is dependent on the context and requirements of the process).

Figure 8.9 illustrates a generic model, which Jones and Saad (2003) argue is representative of the perspective of the producer of the innovation. The principles of this model are adapted to the findings of the research in figure 8.10, and represent the innovation process within the construction project environment. The generic nature of Rosegger's (1980) principles were adapted to reflect this context without much trouble. The starting 'idea', at the centre of Rosegger's (1980) model, reflects the emergent nature of this process. The nature of the emergence of ideas within the construction project is better described as the recognition of the 'need to innovate'. This allows the reflection within the construction project that innovation can be imported from external sources or generated internally. Within Rosegger's producer based innovation model, the nature of the idea's emergence within the process is not an issue for consideration.

In the adapted version of the model, the point of recognition relating to the 'need to innovate' represents the beginning of the process. This is followed by a period of activities (idea generation) geared towards putting together proposals for the formulation and development of the concept. Failure to achieve permission to progress at the first decision point results in either the termination of the process, or the re-evaluation of the proposals. Permission to progress results in activities associated with the development of the innovation, such as planning and assessments of feasibility. The outcome of these activities is the formulation and development of proposals for the

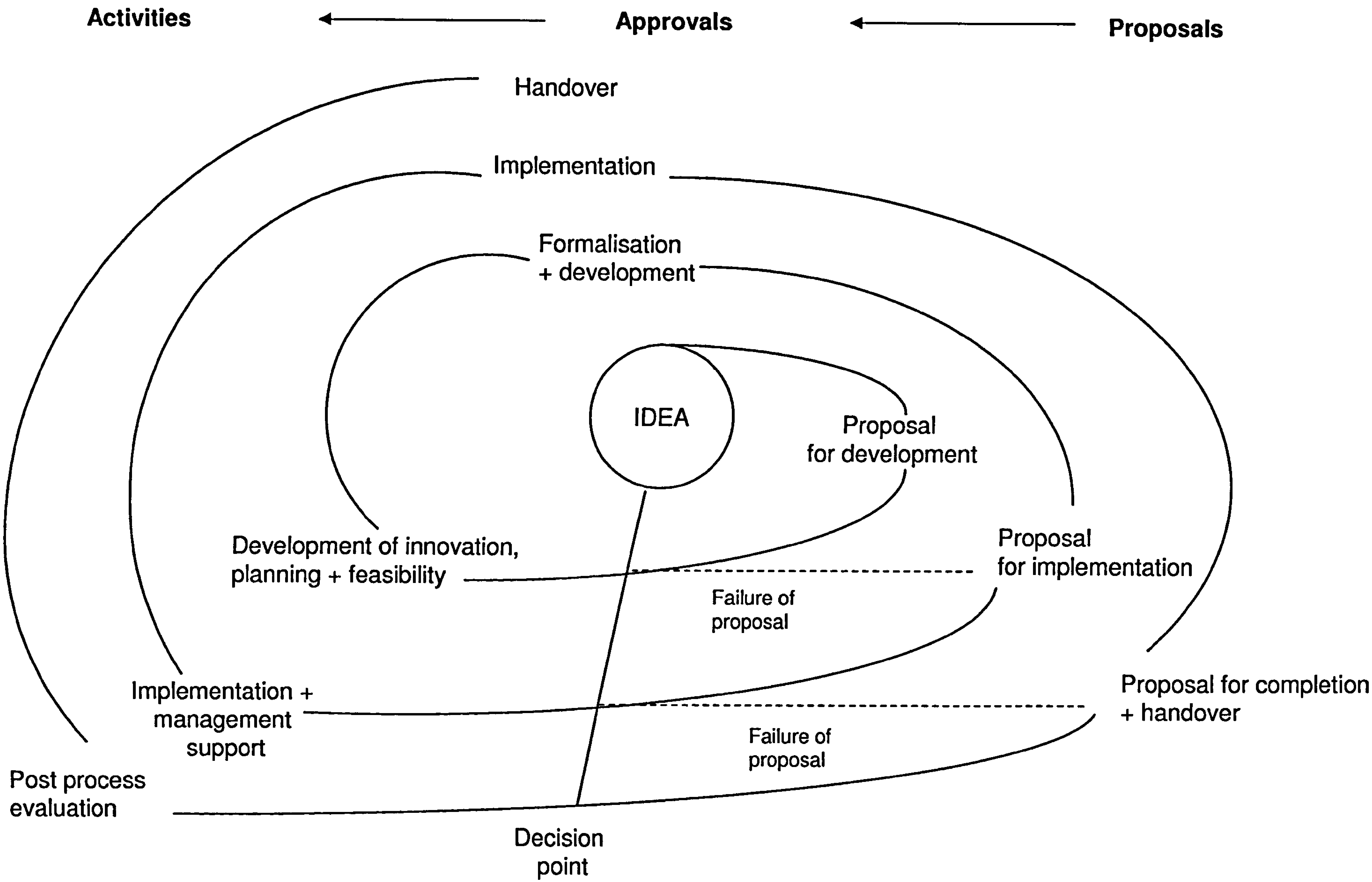


Figure 8.10: Adapted version of Rosegger's (1980) model of innovation from research findings

implementation of the concept into the practical realities of the project environment. These proposals form the body of the case for assessment by management regarding the decision to implement. Failure to achieve permission results in either the termination of the innovation process, or the re- evaluation of the proposals. The progression of the process marks the permission for activities associated with the implementation of the innovation in practice and its management support. The completion of implementation is achieved by management being satisfied that the proposals for handover are met and ready to be applied. The consequences of a failure to satisfy management that the process had reached this point results in either the termination of the innovation during implementation, or the re- evaluation of the activities adopted during implementation. The completion of the model is illustrated by handover, which involves the activities relating to the future of the innovation and an evaluation of its performance, in addition to a post- evaluation process.

The principles behind the adapted version of Rosegger's model significantly ties in with the nature of the phase and decision gates of the research model. Rosegger (1980) disagreed with the use of decision gates, and favoured to stay away from this description of the decision points, feeling that the term 'gate' imposed a structural feel to an emerging and fluid process. However, under closer examination, it appears that the description of the creation of a set of proposals, and the need to achieve management satisfaction for progression of the process, is very similar to the principles outlined for the decision gates in the research model. The activities of each phase within both the adapted version in figure 8.10, and that of the research model, are also noted to be consistent. The principles laid out in chapter 6 regarding the fuzzy, fluid nature of each phase of the process, accommodate the need to retain a reactive process.

Through this, Rosegger's concerns regarding the description of decision gates through the potential that they become structurally restrictive are not represented within the research model. The principles of the research model outline the revisiting of activities in a similar manner at the decision gate, until satisfaction is achieved.

The representation of the innovation process as a spiral in Rosegger's (1980) model provides a significant advantage over the style of representation achieved within the research model. Within the research model, feedback from the decision gate to the individual phase was described as occurring automatically within the individual phase through revisiting of activities is the phase until it was satisfied, although it was not represented visually. Cooper's (2001) stage gate model also fails to visually represent this element of the process, but acknowledges it to be a function behind the rational of each decision gate and its proceeding phase. Rosegger's (1980) representation of feedback from each decision point strengthens the appreciation of this component of the process, and is an aspect that should be considered for inclusion within the research model.

The research model contrasted with Rosegger's (1980) representation of the innovation process through the visual inclusion of the overall innovation management of the process. Rosegger (1980) potentially steered away from the representation of this component of the innovation process for similar reasoning as Van de Ven et al (2000). He aimed to display the activities and nature of the innovation process, and not the management of the process as in the research model. As a result, the inclusion of the overall innovation management of the process is not necessary to the same extent in Rosegger's model.

The research model illustrates the role of the overall innovation management in achieving feedback on the progress of the process throughout, significantly incorporating this at the end of the process (the post process evaluation). Rosegger's (1980) model illustrates no indication of such feedback, which is an element of strength shown by the representation in the research model. The failure of Rosegger to represent this aspect of the innovation process is surprising given the emphasis on feedback during the progression of the proposals of the process.

The research model, in its representation of the innovation process, included the display of factors of influence such as internal project and external environmental factors. This is an aspect missing from Rosegger's representation, and is an aspect that requires consideration during any innovation process, as facilitation methods are required by management to accommodate such factors. Rosegger's focus on the innovation process itself, and not the requirements of its management, influence this decision not to represent these factors. However, to represent them in the manner of the research model provides an acknowledgement of their influence on the process.

A comparison of the adapted version of Rosegger's model with the research model validated the conceptual understanding and function of the decision gates and the individual phases of the innovation process identified. The different style of representation, with Rosegger's focus on the process as opposed to its management, highlighted the need to increase the visibility of the feedback between the decision gates and the proceeding phases within the research model. The shared emphasis between the two forms of representation for the fluidity of the individual phases is important, validating the emphasis placed on this aspect in the description of the phases. The adoption of the principles of Rosegger's to the context of the research, provides an effective means of validating the decision gates and phases of the innovation process, in order to ensure that it is fully developed. This will be achieved after adjustment of the representation of the feedback between the decision gate and the phases.

8.3 Validating and improving the research model

The validation process of the research model revealed two significant observations; firstly, the verification of the structure and dynamics of the model, and secondly revealed two improvements that would improve the visual representation of the principles of the model.

- **Validation of the structure and dynamics of the model**

The application of the four styles of representation for modelling innovation to the context of the construction project environment, when compared to the research model, validated its structure and dynamics. The non- linear push/ pull representation of Burgelamn and Sayles (1986) identified many commonalities with the initial phase of the research model. The application of the principles of this model revealed a contrasting form of representation that does not replace the research model, but enhances understanding of the process in this early phase. This adaptation of the principles of this model did not provide a validation of the structure or dynamics of the research model, but identified a consistency in activities and factors of influence observed within the initial phase of the research model.

When considering each of the innovation process models in their original format, comparison with the research model revealed many distinctions in the phases and decision gates. However, when the principles of these models were adapted to the construction project context, the distinctions became similarities. The style of representation of the adapted versions of the models differed, however the nature of the phases and the identification of the decision gates remained constant. This is a significant observation, as it indicates that the principles of Cooper (2001), Van de Ven et al (2000) and Rosegger (1980), when applied to the construction project context, did not produce a different set of phases and decision gates from those emerging within the research. Each of the original models display a representation of the phases and decision gates identified within a given contextual environment and thus they reflect the nature of the innovation process within this context.

The contextual nature of the phases identified in innovation models is reflected in the product development models of Cooper (2001) (considered in this chapter), Wheelwright and Clark (1995) and Dooley and O'Sullivan (2000). These models are geared towards the innovation's launch to market, and thus display the implementation phase outwith the innovation process. Figure 8.11 displays a comparison of a range of other models against the phases identified in the research model. Although the terminology used to describe the different phases contrast, the principles of each model are formulated under a similar conceptual framework. These contrasts reflect the context of the model's representation, in the same manner that the three innovation process models discussed in this chapter are reflective of context in their original form. Analysis of the range of innovation process models reveals that it is possible to observe four generic phases existing within the innovation process as 1) idea creation, 2)

Phases of research model	Rogers (1983)	Kimberly (1981)	Zaltman et al (1973)	Harvey and Mills (1970)	Wilson (1966)	Jones and Saad (2003)	Francis (2003)
Initial phase	Initiation		Initiation	Issue perception	Conception of change	Identification of the need to innovate	Idea acquisition
Formulation + Development phase				Formulation of goals Search Choice of solution	Proposing change	Knowledge awareness	Idea adoption
Implementation phase	Implementation	Adoption Unitisation	Implementation	Redefinition	Adopting and implementation	Implementation	Idea application
Handover phase		Exnovation					Idea exploitation

Figure 8.11: Comparison of selected models with the phases of the research model

development, 3) implementation and 4) review phase. This is a general process, and the terminology and nature of the phases differs in relation to the context of the environment to which it operates in practice. The phases of the research model, due to the nature of the construction project, identified four phases that align themselves with the principles of these generic phases adapted to this context.

The three innovation process models compared within this chapter, each represented a different style. As a result, each gave a differing interpretation of the innovation process, reflecting differing aspects. The emergent model of Van de Ven et al (2000) and the spiral model of Rosegger (1980) both represent the journey of the innovation process, and not the management of this process in the manner of both Cooper's (2001) model and the research model. Van de Ven et al (2000) and Rosegger (1980) both disagreed with the need to impose the structure of management on the innovation process, as they felt it restricted the fluidity and emergent nature of the process. However, for the purposes of the context of the construction project, a more structural or functional approach was required to be represented within the model due its increased focus on the management of the innovation process. The representation of the overall innovation management of the process within the research is a good example of the identification of this, due to the nature of the context for demonstrating this aspect of managing the innovation process. Due to the nature of the construction project environment, the research model needed to represent a management process that is proactive in its approach but also retained many of the reactive qualities of Van de Ven et al (2000) and Rosegger (1980). The use of the decision gates and the overall innovation management of the process provide the proactive structure, and the individual phases, although outlining the management activities to achieve the necessary objectives, retain the ability to be fluid, flexible and fuzzy by their nature. Through the consideration of the implications of adopting the principles of other models to this context, the research model is validated as a functional linear sequence existing at a high level of the process that is matched by the need for the nature of the individual phase processes to represent its emergent fluid and flexible nature.

- **Improvements to the research model**

Three improvements are identified from the chapter that aid the visual representation of the principles of the model. The first improvement suggested is the inclusion of a feedback loop from the decision gate to the previous phase. This aims to represent clearly the revisiting of the phase when authority for progression is not granted at the decision gate. This was an assumption of each of the phases of the research model, however was not formally included within the model. This improvement stems from consideration of Rosegger's (1980) illustration of feedback between the decision point and the activities that precede it.

The second improvement, stems from consideration of Cooper's (2001) stage gate model, and concerns the effective communication visually of the function of the individual decision gates by naming them within the model. Within the research model, the decision gates were represented by an arrow that was numbered, and their function was outlined in the discussion in chapter 6. Cooper's display of the function of each decision gate allows the reader to understand the function of the decision gate, and therefore the purpose of the proceeding phase from the diagram alone.

In figure 6.1, the decision gates were represented as an arrow, in the same manner as Cooper's stage gate model. However, because of the inclusion of the feedback loop from the decision gate to the preceding phase, it was concluded that the illustration of the decision gate as a four-sided diamond would improve the reflection of its function. This is the standard representation of a decision gate within flowcharts, and allows the reader to relate to the concept that the decision either is approved or rejected using symbols they are familiar with.

These alterations to the research model are displayed in figure 8.12, where the final version of the research model for managing the innovation process within the construction project environment is presented. These improvements do not change the principles of the model, however, they aim to aid its visual communication to the reader.

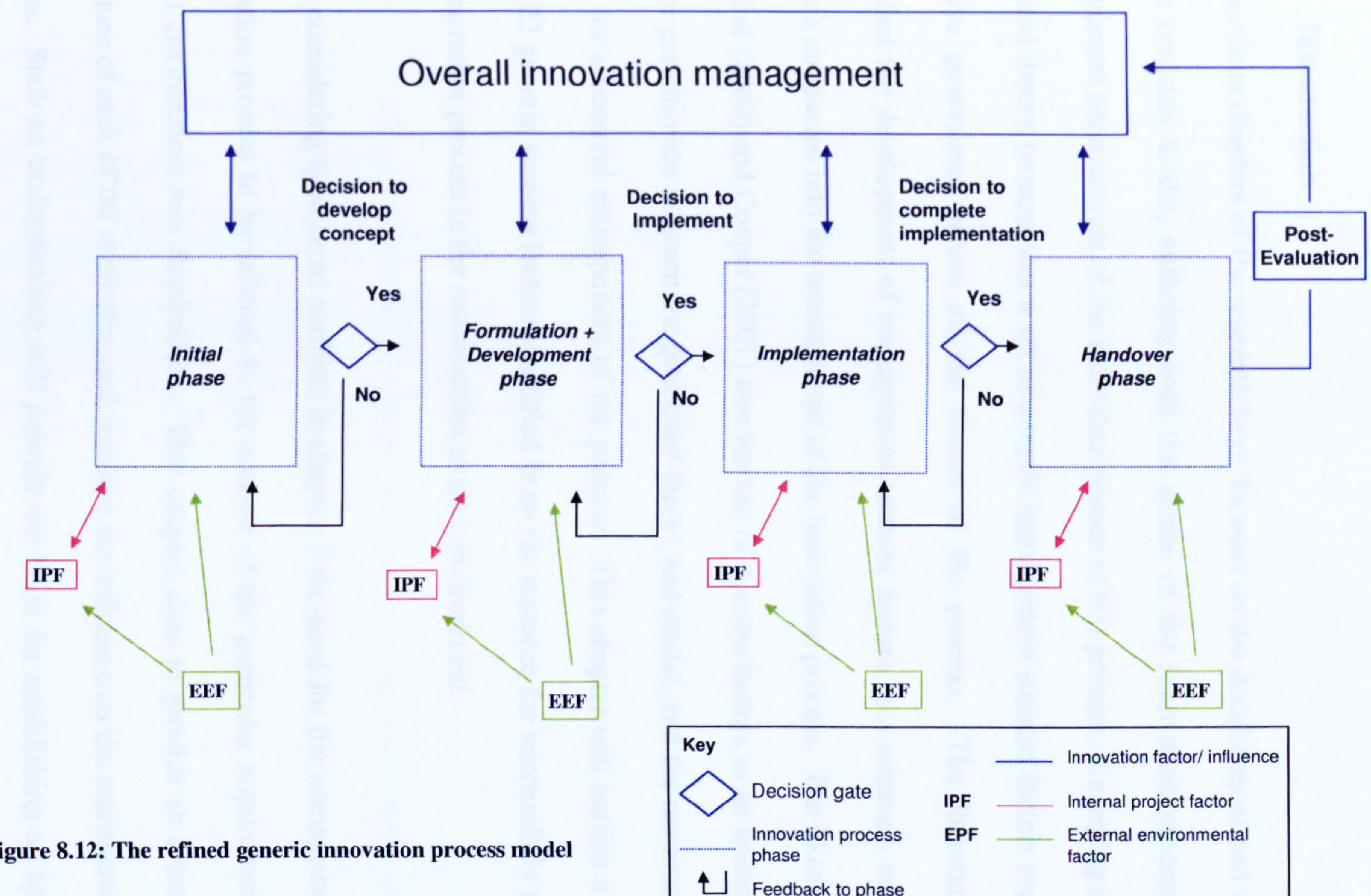


Figure 8.12: The refined generic innovation process model

Chapter 9

9 Successfully managing the innovation process

9.1 Introduction

The previous chapters of the research have focused on the development and validation of the research model, outlining both the nature of the innovation process and the management requirements of the individual phases of this process. Emerging during the grounded theory process was a set of generic management success factors required for effective governance across all the phases of the process. The literature review identified the development of management success factors as a common output from research conducted into the management of the innovation process. The likes of Van de Ven et al (2000) and Cooper (2001) saw the use of success factors as an understandable link for practitioners between the generated theory and model, and the requirements and needs for successful management of the process. This chapter will outline a common set of 22 generic success factors identified from the research for successfully managing the innovation process in the construction project environment.

When considering type as an attribute in chapter 7 the need for the management of the innovation process to be tailored to the context of the particular requirements of the project environment was emphasised. This chapter aims to provide an assessment of the nature of each of the attributes, and consider the influence on the management of the process. Such an understanding will provide the basis for establishing an appropriate management response to the form of each of the attributes presented, with reference to the wider generic success factors. This discussion provides the basis for the development of a tool to consider and display the facilitation needs of the form of the attributes as a set, allowing management to tailor their response in a manner appropriate to the particular context.

9.2 Success factors

During the analysis of the case studies, 22 generic success factors for managing the innovation process emerged. The research model identified success factors for each of the elements of the individual phases of the process, revealing a complex and dynamic set of requirements for management consideration. Assessment of the individual phases of the research model revealed a close alignment between the factors requiring satisfaction for success. Consideration of the individual phases of the research model, highlighted the tailored nature of the factors to the function of the phase, but revealed that the underlying themes of many of these factors are shared across each of the phases. Comparison between these themes, and the 22 generic success factors, revealed a close alignment. Figure 9.1 presents the 22 success factors for the management of the innovation process within this context.

The research identified that the 22 success factors can be split into three groups, the strategic (5), structural (10), and cultural (7) aspects and needs of the innovation process. The strategic factors were concerned with the overall management needs of the innovation process, i.e. its integration with the project environment. The structural factors referred to the structuring of management support for the process, i.e. clearly defining roles, provision of resources and intervention within the process. The cultural factors related to the facilitation of the cultural needs of the innovation process, i.e. the facilitation of the team's interaction with the process through the creation of a

Generic success factors for managing innovation within construction projects		
Strategic	**Structural**	**Cultural**
1 Ensure and facilitate the integration of the aims/ objectives of the project with those of the innovation (project level)	6 Top- level participation (providing leadership and control)	16 Create, acceptance and understanding
2 The establishment of an innovation culture/ methodology	7 Ensure access and involvement provided to the entire team	17 Participation and involvement
3 Engagement with industry/ government agenda's -regulation and external environment	8 Develop the knowledge base	18 Proactive innovation culture
4 Ensure project standards are met	9 Ensure monitoring of the process	19 Creativity and problem- solving culture
5 Integration of the cultural needs of the team- (team level)	10 Facilitate communication and information pathways (listening culture)	20 Continuity and stability of the team
	11 Clearly define roles and responsibilities	21 Team relationships
	12 Selection of a facilitating team	22 Project performance
	13 Ensure sufficient lead in time and resource allocation	
	14 Provide management support system	
	15 Develop and provide, technical and financial assessment	

Figure 9.1: Generic success factors for managing the innovation process within construction projects

facilitating cultural environment. The following section will firstly present these factors individually emphasising their influence to the management process, and secondly validate them against success factors identified within established research.

9.2.1 Success factors

Strategic factors

(1) Ensure and facilitate the integration of the aims/ objectives of the project with those of the innovation (project level)

The integration needs of both the innovation and project processes has been identified throughout the research as a significant factor affecting the success of the management of the innovation process. Case study (2) illustrated the problems emanating from a lack of management consideration for the integration of the processes, culminating in the termination of the innovation's use within the context of the project. The nature of the construction project environment requires that the aims and objectives of both processes be integrated in a clearly functional and beneficial manner for them both in order to successfully facilitate progress. Case study (3) provides an example where management recognised the need for integration, allowing the innovation and the project processes to develop interdependently.

(2) The establishment of an innovation culture/ methodology

The case studies having an established innovation culture/ methodology were more successful in managing the innovation process. Three of the case studies (i.e. wind turbine, roof insulation and case study (3)) all illustrated the benefits of an established innovation culture and methodology. The wind turbine case study, for example, was an in- house project within a very pro- innovation-manufacturing organisation. Therefore, team members brought this cultural outlook to the project, providing both a supportive and encouraging culture towards the innovation process. In addition, the management of the innovation process followed an established structure, familiar to team members, as it represented the standard method for managing innovation within the rest of the organisation. The research highlighted that the multi- party projects, with the exception of case study (3), displayed characteristically poor levels of achievement for this factor. The traditionally temporal nature of the team's relationships does not inherit an established culture towards innovation, in the same manner as the wind turbine case study. The absence of both an established culture and structured methodology to approach the process requires that facilitation is needed to generate one. Case study (3), despite being a multi- party project, was the only multi-party case study to actively seek to generate such a culture. Assessing the case study demonstrated the benefits of facilitating such a culture, and enabled its development with a structured approach to its management. This approach was predefined with an outlined structure of activities for the process, aiding the creation of a cultural atmosphere and approach that was supportive of innovation.

(3) Engagement with industry/ government agenda's- regulation and external environment

External factors of influence provide the background in which the innovation process takes place. Analysis of the case studies revealed that management who are engaged with the industry's and government's agenda enjoyed success during the management of the innovation process. The system case studies provide a good example of innovation processes that are stimulated by the awareness of management of the positive industry and government agenda pushing its use. The engagement of management with regulatory bodies was also highlighted to be of benefit to the management of the innovation process. Consultation with outside bodies and experts allows management the opportunity to increase their knowledge base regarding the innovation, and ensure awareness to potential external threats. The reed bed case study provides a good example, where consultation with the regulator SEPA actively facilitated the innovation process through their advice and resultant contribution. Management should engage with the external environment in order to be able to facilitate opportunities, in addition to assisting the innovation process.

(4) Ensure project standards are met

The same technical and management standards were noted to be applied to both the project and innovation processes in the successful case studies. Maintaining a constant standard is important within construction projects generally, however due to the high level of uncertainty surrounding the innovation process this issue takes on considerable significance. The grass roof case study highlights an example where the need for constant standards were understood, resulting in the effective integration of the innovation within both the design and construction phases of the project. The successful consistency of standards was achieved by an approach to managing the innovation that is aligned to that taken for managing any other element of the project. Case study (2) illustrates where such an alignment was not achieved, and therefore the standard of the management of the innovation process, was noted to be considerably lower than that adopted for other elements of the project. For example, the level of detail and attention placed on managing the design process within this case study produced an effectively planned and managed process. By contrast, the levels applied to the management of the innovation process resulted in a process that was disorganised and ill conceived. Applying the same standards within both the innovation and the project enhances the potential for the successful integration of these processes.

(5) Integration of the cultural needs of the team- i.e. individual objectives of the project (team level)

In addition to integrating the objectives of both the project and innovation processes, there is a need to integrate effectively the cultural needs of the teams responsible for these processes. The research identified that it is common for different teams to be responsible for the individual processes, producing a need therefore to ensure that they are integrated culturally in order to facilitate the process. An example of this was supplied within the passivent case study where the design team strongly supported the use of the innovation, whereas the overall project team, including the client and contractor did not. The lack of cultural integration between the teams resulted in a lack of understanding of the other side's perspective. Poor communication pathways and the lack of a shared vision regarding many elements of the project contributed to this problem. Consequently, the innovation was dropped from the overall project due to the failure of the innovation team to engage and integrate effectively with the objectives of the project team. Improved integration between the teams would have provided the opportunity for either a compromise to be developed, or the realisation by the design team that the innovation was simply unsuitable for the project. Examples such as the grass roof case study provide evidence illustrating that through facilitation of the cultural integration (i.e. their relationships and communication pathways), a shared objective between the teams can be achieved.

Structural factors

(6) Top level participation (providing leadership and control)

The research identified the significance of the participation of top- level management as a success factor for managing the innovation process. Top- level management was illustrated to provide leadership and control to the innovation process, thus allowing a more successful satisfaction of the remainder of the success factors. The contrast in the experiences of the system innovation case studies highlights the influence that this factor can have on the performance of the innovation processes. During the implementation phase of case study (1), top- level management devolved responsibility for the innovation process within the project team. What had been a well-managed process up until this point, experienced serious problems accommodating the pressures of the project. Those with devolved responsibility for the innovation process, allowed project pressures to affect the implementation of the innovation to the extent that it was dropped. Top- level management failed to monitor the progress of implementation, and did not provide the leadership required to maintain control of the process. Case study (3) provides an example where top- level management maintained leadership and control of the innovation process throughout due to their continued participation within the process. Top- level management were able to facilitate the activities of the implementation phase against the pressures exerted from the project, through careful monitoring and strong leadership. The participation of top- level management enables the effective integration of the innovation and project process by monitoring and facilitating the maintenance of their appropriate relationships.

(7) Ensure access and involvement provided to the entire team

The level of involvement of the team within the innovation process is highlighted during analysis as a significant factor. A management that structures the opportunity for access at the earliest possible point to the entire team was illustrated to achieve a greater degree of involvement and ownership within the team throughout the process. Evidence within the case studies showed that providing all the stakeholders of the project with access and resultant involvement with the process enhanced their contribution towards the process due to their feeling of empowerment within the process. Case study (3) demonstrated the benefits provided to the process through the provision of access to the entire team throughout the process. Team members such as the structural engineer felt comfortable and motivated to make suggestions for improving the innovation, over the course of the process. Case study (2), by contrast, failed to achieve the same level of access within its team, contributing to the contractor's failure to develop feelings of ownership for the innovation and withdrew from any involvement to assist the innovation within the project. The lack of ownership for the process resulted in the contractor focusing entirely on the needs of the project process, with no regard for those of the innovation. Analysis pointed to the root cause of this as the lack of access provided to the contractor early in the process.

(8) Develop the knowledge base

Those involved in an innovation process can always gain from the development of their knowledge base relating to the concept and its management. Analysis illustrated that where participants actively seek to develop their knowledge base, through the consideration of both research and the experience of others, the other case studies enjoyed greater levels of success. Evidence illustrated that it was equally important for internal and external sources of research and experience to be considered during this process. The reed bed case study for example benefited from both sources, with the expertise and experience of the designer being heavily utilised by the rest of the team, in addition to consultation with external sources such as SEPA. Case studies placing a structural necessity for fulfilling this factor clearly enjoyed an advantage over those that did not. The wind turbine case study, for example, achieved a considerable reduction in the level of uncertainty relating to the innovation through such activities. Within this example, the increased confidence that developed from increasing the knowledge base within the team highlights the significance of this factor. Structuring these activities into the innovation process from the earliest possible point enhances the potential for the team to make informed judgements during the innovation process that increases the chance of success.

(9) Ensure monitoring of the process

Analysis of the case studies revealed that management who make provision for monitoring the performance of the innovation process greatly enhances the potential for its success. Monitoring of the innovation process by management can be either informal or formal. The grass roof case study demonstrated an example where management used regular project meetings to monitor the performance of the innovation process. This contrasted to the approach of case study (3) where the high level of involvement that top- level management had with the activities of the process meant that they continually monitored its performance informally. Effective monitoring allows facilitation to be deployed as and when it is required. Case study (1) highlights an example where the devolution of responsibility for the process from top- level management to the remainder of the project team resulted in a failure to monitor the progress of the innovation process, either formally or informally. Top- level management were out of touch with the needs of the innovation process and failed to adapt the process due to changes in the circumstances. Innovation management requires a management that is engaged and reactive to foreseen problems and the provision of a monitoring system using a mixture of formal and informal approaches greatly enhance this.

(10) Facilitate communication and information pathways (listening culture)

Analysis revealed that case studies that actively facilitate the communication and information pathways between team members, enjoyed clear benefits when managing the innovation process. The facilitation of these pathways involved two sets of activities, those aimed at providing structure for the pathways, and those aimed at supporting the cultural relationships between team members. Both sets were observed to enhance the quality of these pathways. The grass roof case study provides an example of the structural facilitation of these pathways, as regular meetings were organised to provide the opportunity for the project team to focus on the innovation. These meetings provided the forum for raising issues and the passing of information between team members regarding the innovation. Case study (3) provided an example of the use of the cultural facilitation of these pathways, as emphasis was placed on ensuring that team members enjoyed a good working relationship. Evidence suggested a clear correlation between teams that enjoy a good working relationship and the effective exchange of communication and information. Management within case study (3) placed considerable emphasis on developing a listening culture, where team members were encouraged to listen and consider the opinions of others before dismissing them. Case study (2) provides a useful example of the failure to facilitate the communication and information pathways between team members during the innovation process. The consequences of this resulted in continual misunderstandings between team members, a lack of clear and available information regarding the implications of the innovation, and a culture within the team where team members failed to listen to each other. Analysis revealed that the quality of the communication and information pathways between team members had knock on implications for issues such as the exchange of knowledge within the team, and the effectiveness of the integration of the innovation and project process.

(11) Clearly defined roles and responsibilities

The research showed the importance of effectively defining the role and responsibilities of the team within the management of the innovation process. Case study (3) provided an example where these roles and responsibilities were defined at the start of the process, allowing team members to understand what their contribution to the process will be throughout and allowing them time to grow into the role. Within many of the case studies, confusion and misunderstandings regarding the team's interaction with the concept was identified to present a barrier to the team's contribution to the innovation process. This came about either through a failure to define these roles and responsibilities at an early stage, or by not actually defining them at any point. This was particularly evident within case study (2), where a failure to define roles and responsibilities resulted in confusion within the team resulting in serious interaction problems with the innovation. To aid a team's understanding of the concept, individuals require to understand how they are supposed to interact with the concept.

(12) Selection of a facilitating team

Case studies, that during the selection process assessed the approach of an individual and their organisation towards the use of innovation within construction projects, experienced lower levels of resistance. The mindset of team members was identified to influence the nature of the interaction of individuals with the innovation and its management. The mindset of a member of the team is defined by a range of aspects such as their individual personality, as well as the approach of their organisational culture towards innovation. During the selection process it is not possible to predict exactly how an individual may approach an innovation, but it is possible to identify individuals that have the potential to be facilitating towards it. Case study (2) illustrated the problems caused by the selection of an organisation (i.e. contractor) with the wrong mindset towards the use of innovation, and the resultant damage to the innovation process that this can cause. Within this case, the contractor was predominantly selected on a project basis (cost, time and reputation), and not on criteria geared towards the facilitation of the innovation. As a result, the contractor's interaction within the process placed the needs of the project process before that of the innovation, due to their desire to use tried and trusted methods for achieving a successful project. This mindset contradicts the requirements of effective integration of the system innovation, where the innovation process governs that of the project. Management potentially could have averted this problem during the selection process through a detailed assessment of the contractor's approach to innovation. The contrast between the negative mindset of the contractors in case study (2), and the positive mindset of case study (3) highlights the impact this can have on the performance of the innovation process. The research identified the potential that control management can be exert over the mindset of the team, through the structuring of an effective selection process that is focused on the needs of managing the project and the innovation processes.

(13) Ensure sufficient lead in time and resource allocation

The research observed a strong correlation between the successful management of the innovation process, and the structuring of a sufficient lead in time and resource allocation during the development phase of the process. The provision of an adequate lead in time prior to implementation was illustrated to assist the understanding and acceptance of the concept within the team. The reed bed case study provides an example where management ensured that permission to implement the concept was denied until the concept was sufficiently researched, developed and understood by the team. The provision of an adequate lead in time allowed team members to become familiar with the innovation and its practical implications. The increased levels of familiarity aided to develop a deeper understanding and acceptance of the innovation within the team, resulting in increased levels of contribution to the process. This contrasts significantly with case study (2) which rushed into the implementation of a poorly developed innovation, supported by a team that had a low level of understanding of the concept and its practical implications. The lack of emphasis placed by management on this factor produced an innovation that was rushed into implementation without many of its details being effectively defined. Team members were not provided sufficient time to absorb the implications of the innovation. The knock on effect of this was that during implementation the innovation was implemented in name only, as people reverted to more tried and trusted methods, due to the lack of understanding. The provision of adequate resources to support and develop the concept clearly determines the effectiveness of the innovation process. The provision of an adequate lead in time can be seen, from a management- planning standpoint, as an effective allocation of the resource of time, which is as important as the allocation of resources such as funding and personal.

(14) Provide a management support system

The structuring of an effective management support system geared towards facilitating the innovation process is required throughout the innovation process. The formal structuring of such a system was observed to some extent within all of the successful case studies. The management support system involves two main functions the monitoring of the innovation process, and the support of the process when required. The need for monitoring the performance of the innovation process was identified as a separate success factor, however, it is a relevant component of the management support system also. In order to support the management of the innovation process, there is a need to carefully monitor the performance of the innovation process to identify when support is required. Case study (3) provides an example of a formal and visible management support system. Structured meetings are used to ensure that management are able to monitor at regular intervals the support needs of the innovation process. A range of predefined strategies was in place for management to draw on when extra support is required, and their selection of use depends on the nature of the problem. The management of this case study identified the need to support the teams understanding of the concept's implications, and provided extra workshops relating to this issue throughout the process. Analysis of other case studies observed that the support provided to the innovation process could be both formal and informal in nature. In the demolition waste case study, management monitored problems emerging regarding the deteriation of the relationship between two of the members of the team.

Management chose to adopt a strategy of informally mediating between the two parties. These examples illustrate different types of support, determined by the identified need. It is necessary for management to have a planned system of support that they can draw on when required. This aids the speed of their response, and ensures an awareness of the need to support the innovation process.

(15) Develop and provide, technical and financial assessment

The research revealed that throughout the process there is a constant need for management to consider both technical and financial assessments of the feasibility and suitability of the innovation's use within the project. The uncertain nature of the innovation process coupled with the changeable nature of the construction project environment, results in a process that constantly needs to assess the suitability and feasibility of its use. A good example of the importance of this activity was the passivent case study, where feasibility assessments revealed that the innovation was not suitable in practice for implementation within the project, due to the changing criteria of the project's design. As a result of these assessments, the innovation was rejected prior to implementation and an alternative was found. Case study (1) demonstrated an example where a lack of an adequate financial assessment, regarding the practical implications the innovation, resulted in spiralling costs following implementation and a lack of understanding of why. This example illustrates the need for management to focus on this factor throughout the innovation process, and not just prior to implementation.

Cultural factors

(16) Create, acceptance and understanding

Culturally a team that fails to accept or understand the use of an innovation will become disruptive to the innovation process. This is evident, to some extent, within all of the system innovation case studies. Within this context, the contractors disrupted the innovation process due, primarily, to a lack of acceptance of its justification for use. Within case studies (1) and (2) the contractors simply withdrew from contributing to the innovation process and resorted to traditional methods of interaction within the project. Evidence supported the realisation that much of these negative affects were rooted in a lack of acceptance of the concept. Closer examination revealed that much of the lack of acceptance was founded on a lack of understanding of what the implication would be. The wind turbine and grass roof case studies illustrate that through facilitation, complex and difficult innovations can be accepted and understood by a team. Within both examples, the teams displayed strong cultural associations with the innovation, due to the recognition of its benefits established through their understanding of its implications. There is a need for management to justify the use of the concept to the team, and to explain fully the implications of its use.

(17) Participation and involvement

Teams that are able to participate and are actively involved in the innovation process were identified to enjoy greater levels of success. The importance of the involvement of the entire team has already been discussed with reference to the provision of access as a structural factor; however, a requirement exists for it to be managed as a cultural factor also. Management needs to develop within a team a desire for their participation and involvement through both the structural and cultural facilitation of these needs. A team that enjoys cultural feelings of ownership and empowerment is observed to illustrate a greater potential for success. Case study (3), although experiencing many of the problems of the other two system case studies, enjoyed a greater level of participation and involvement from the team within the process of the innovation. Management encouraged the entire team to get as much involvement in the innovation process as possible, as a means of gaining experience for future projects. Culturally this provided an incentive for team members to be involved and to make an active participation in the process. This resulted in the process being easier to manage through the increased levels of ownership and empowerment felt by the team towards the fortunes of the process. As a result, the structural engineer felt comfortable to contribute actively in the future direction of the innovation. Through the development of a culture that promotes active participation and involvement, the levels of ownership and empowerment of team members within the process aids to the process through the benefit of their contribution.

(18) Proactive innovation culture

This factor was identified as providing significant assistance to the management of the innovation process. In order to achieve this it requires to be facilitated culturally, both through its establishment at the beginning of the process and supported thereafter. A proactive innovation culture naturally facilitates a team's engagement with the process and supports a questioning culture as the team try to seek continual improvement within the process. The in- house managed projects, such as the wind turbine case study, were identified as being more successful in achieving this factor, through their established cultural environment that has evolved over time. Individuals within this innovation process needed to feel that their contribution provides both value to the innovation process, and to themselves. Case study (3) highlights, however, that these qualities are not impossible for multi- party projects. This is highlighted within this example by the recognition by the structural engineer of the value of engaging with the innovation process in a proactive manner. This provided an example where the entire team engaged with the process in order to achieve its improvement, and the team felt comfortable questioning the innovation and its implications. This comfort stems from a desire throughout the team for improvement within the process, and a cultural environment that encourages the contribution of the entire team. The development of a proactive culture by management is essential to creating the correct cultural atmosphere where team members want and feel obligated to contribute both for the development of the project, and for themselves.

(19) Creativity and problem- solving culture

The research revealed that a successful innovation process generally enjoys a creative and problem solving culture. These attributes are necessary for both idea generation activities, in addition to the problem solving capabilities required for improvements to the concept and the process. Assessing the case studies, it was apparent that creativity and problem- solving were characteristics that required encouragement culturally by management. The association noted, for example, in case study (1), between these aspects and that of risk, stifled the ability of the team to adapt the innovation process to the needs of the project. The grass roof case study was particularly effective in promoting this activity and benefited continually throughout the innovation process as a result. The ability of the team to think outside of the box and to be flexible in their approach to the design of the project can be traced back to the creative and problem-solving culture initiated by the management. This aspect was facilitated within through the creation of a group culture where the team are open to new ideas and actively seek improvements. The cases studies highlighted the need to develop such a culture, as not only producing innovation ideas, but also to ensure that the team are able to be flexible in their interaction within the process.

(20) Continuity and stability of the team

Analysis identified that teams which are stable throughout the process enjoy a greater degree of success with managing the innovation. Traditionally the construction project environment proves a difficult place to retain stability of the team's membership due to the nature of the production process. However, the case studies demonstrated the link between the continuity and stability of the team and the success of the innovation process. Serious problems arose within case study (1) when half way through new members replaced the contractor's team. The new team members brought in a different mindset towards the innovation that was negative in nature. These individuals focused on the needs of the project as opposed to the innovation, and as a result caused problems for those managing the innovation process. The wind turbine case study provides a contrast to this experience as the team membership remaining constant throughout. The in- house nature of the project promotes stability within the team that is difficult to achieve in the multi- party projects such as case study (1). Whilst team members may change, they will be experienced with the nature of the organisations culture, and therefore retain continuity.

Despite the importance of this factor, further analysis revealed who disruptive team members that damage the innovation process should be removed, at the expense of retaining continuity and stability. The demolition waste case study provides an example where for the benefit of the process, the client representative was replaced. Although the new individual did not enjoy the same level of understanding of the process, they proved to be less disruptive and confrontational in their approach. On the whole management require to keep cultural disruption within the team to a minimum, and this is facilitated by maintaining both the continuity and stability within the team.

(21) Team relationships

The research revealed the benefits of facilitating the relationships between team members as aiding the management of the innovation process. The strength of the relationships between team members was identified to facilitate a multitude of aspects such as aiding communication pathways, decision- making processes, tolerance levels for mistakes in the process, issues of trust between members etc. Case study (3) demonstrated an example where management recognised the need for facilitating this factor. Management from an early point in the process adopted the use of workshops and additional meetings in an attempt to facilitate the relationships within the team. Management identified the need to aid the creation of a group culture within the team, where members contribute for the good of the team as opposed to themselves. The recognition of these factors within case study (3) is in contrast to case study (2), where management felt that the relationships of the team would naturally evolve over the course of the process. Evidence illustrated that it was dangerous to take such an approach, as no guarantees exist that this would occur. The relationship between the design team and the contractors remained strained throughout the process, and the lack of facilitation meant that resolution of these tensions was difficult to achieve. The quality of the relations within this example particularly affected the passing of information relating to the innovation, and resulted in considerable confusion and mistakes being made during implementation. A good team relationship greatly enhances the management of the innovation process, and provides a basis for the facilitation of many of the other cultural factors.

(22) Project performance

The research identified the considerable impact that the performance of the project can have on the cultural approach of the team towards the innovation process. Many of the case studies illustrated the effects of poorly performing projects and highlighted the negative impact that this has on the teams approach to the innovation process. The grass roof case study provides an example where the successful progression of the overall project had a positive impact on the culture of the team with regard to their approach to the innovation. Case study (1) provides a contrast, where the poor financial and timescale performance of the project, influenced the cultural atmosphere of the team towards the innovation process. Management was required within this to protect the innovation process from the negative pressures of the project. However, they failed due to a lack of awareness, resulting in the abandonment of the innovation process in order to accommodate the perceived needs of the project. This example highlights the need for system innovations, in particular, to protect the team culturally from the temptations to abandon or adapt the innovation process, due to pressures from the project process. Case study (3) provides an example where the use of additional project meetings provided the opportunity for the team to air their concerns, and for solutions to be found. The facilitation of a team's culture during periods of project problems is necessary for reducing the affects of panic surrounding the use of the innovation process.

9.2.2 Validation of the factors

A comparison of each of the individual success factors, against seven established sets of success factors for the management of innovation from general management was conducted. The comparison was structured under the themes strategic, structured and cultural, and compared the research factors produced by Cooper (2001), Francis (2000), Dooley and O'Sullivan (2000), Tidd et al (1997, 2003), Jones and Saad (2003), Ahmed (1998) and Rothwell (1994). The comparisons are presented in appendix (D) using the themes of strategic, structural and culture. Two issues were observed to characterise the differences between the sets, the number of factors, and the contextual nature of the factors.

22 success factors emerged during the research analysis for the management of the innovation process within the construction project environment. This is compared to Dooley and O'Sullivan (2000) who established five broad success factors for the management of the innovation process. Consideration of these two sets of factors reveals that they are valid for their context and for the objective of their representation. The construction project based set of factors produced within this research are founded upon a specific environmental context, and this allows the factors to be detailed in their nature and application. Dooley and O'Sullivan (2000), for example, produced a set of factors (pillars) based for a wider generic context, where it is difficult to be as specific or as detailed due to the uncertain composition of the environment of the innovation process under discussion. Cooper (2001) on the other hand identified a specific environment from which to produce a model and consequently was able to produce a more specific set of factors geared towards the particular needs of that context. This would suggest that the greater the definition and understanding of the environment, the

greater the level of detail and number of success factors that can be produced, as the factors are tailored towards the specific needs of innovating within this context.

Assessment of this set of factors, against the seven established sets of success factors, reveals the contextual nature of each set of factors. Cooper (2001) for example displays a set of factors that relates to the management needs for an innovation process that are reflective of product development in the organisational context. Jones and Saad (2003) displayed a set of factors that represented the needs of managing the innovation process within the context of a construction organisation. These differ from the set of factors identified within the research, but these differences tend to be factors that are tailored to the needs of their own particular context. Assessment of the distinctions between the seven sets of factors and the 22 identified here show that the underlying themes of the management of the innovation process are clearly consistent, with the nature of the factors being determined by the needs of the context to which these principles are applied.

In addition to the 7 sets identified in appendix D, Egbu (2004) observed 6 core competencies reflective of organisational innovations within construction. He observed a need for 1) support from top- level management, 2) flexible communication pathways, 3) a risk tolerant climate, 4) culture of valuing team members and allowing them to develop ownership for the concept, 5) shared culture of openness and sharing, and 6) climate of security. All of these competencies were observed to be equally as relevant within the project environment as they are for the organisation within construction when considering the 22 success factors within this research. Although reflective of the contrasts in their context, the factors again appear to share a common set of principles for managing innovation behind which to tailor the management response to the respective context.

9.3 Facilitating the innovation and project attributes

This section of the chapter aims to assess the influence that the form of each attribute identified in chapter 3, has over the innovation process and to outline the management implications for their facilitation. This section splits into three sub- sections in order to explore these facilitation requirements. Sub- section 9.3.1 provides a refinement to the attributes identified in chapter 3, with the replacement of the innovation attribute of scale with that of complexity, and the inclusion of an additional project attribute, management capability. This provides the basis for understanding the individual management requirements of the form of each attribute in section 9.3.2, outlining individually the success factors targeted for additional levels of facilitation. Section 9.3.3 compiles the additional facilitation needs of the form of each attribute into a management facilitation grid. The grid aims to provide a tool for practitioners to be able to identify the additional facilitation requirements for their particular context, based on the understanding of the form of the attributes as a set.

9.3.1 Development of the attributes

The identification of the nature of each of the attributes in chapter 3, formed the foundations for the selection process of the case studies, and provided the initial framework for developing the understanding of the context within which the innovation process is managed. During the analysis process an assessment of the assumptions made in chapter 3 was conducted, to assess their consistency with the practical nature and influence of the attributes in real life. This assessment allows for the development of a deeper understanding of their influence and practical management implications. The results of this process revealed that, with the exception of the innovation attribute of scale, all the assumptions were valid in their appearance. This sub- section outlines the refinement of the innovation attribute of scale, and introduces the more reflective attribute of complexity, in addition to identifying the addition of the project attribute of management capability. Figure 9.2 provides a grid displaying the nature of each of the attributes for the individual case studies. Sub- section 9.3.2 provides a detailed assessment of the practical observations made regarding the form of the influence of each of these attributes.

- **Complexity**

The initial inclusion of the innovation attribute of scale represented an attempt to provide an indicator within the selection criteria, to ensure a spread of case studies for this attribute. However, analysis revealed that a better representation is for an attribute reflecting complexity. It was observed that to consider the attribute of scale purely reflected the change that the innovation represents from the existing practice. Consideration of the case studies revealed that this issue in practice does not pose an influence for management, but instead attention needed to be given to the level of complexity that the innovation poses during implementation. For example, it was noticed that the knock on implications of some innovations to other aspects of the project might be significant, although the actual innovation as a concept may be regarded as incremental concerning its scale of change. The passivent case study represents a good example for this aspect, as although the innovation demonstrated an incremental scale of change from the existing arts, its impact on the project as a whole presented management with an unacceptably high level of complexity. For the context

	Innovation attributes			Project attributes		
Attribute / Project	Type of innovation	Source of idea	Complexity	Funding regime	Management style	Management capability
Roof insulation material	Component	External	Low	Private	In- house	Low
Reed bed Gully waste	Process	Internal	High	Private/ public	In- house	Low
Wind Turbines	Process	External	High	Private	In- house	Low
Grass roof	Component	External	High	Public	Multi- party	Low
Case study (3)	System	External	Low	Public	Multi- party	Low
Passivent	Component	External	High	Public	Multi- party	High
Recycled Demolition waste	Process	Internal	High	Public	Multi- party	Low
Case study (2)	System	External	Low	Public	Multi- party	High
Case study (1)	System	External	Low	Public	Multi- party	High

Figure 9.2: Form of each attribute by case study

of managing innovation within construction, the attribute of complexity reflects the challenge of achieving effective integration of both the innovation and project processes. Evidence identified that the higher the level of complexity, the greater the emphasis on management to facilitate the innovation. Figure 9.2 includes the display of the attribute of complexity and the use of the term high or low as the indicator representing the differing nature of the attribute. The implications for management of the differing nature of this attribute are discussed in 9.3.2.

- **Management capability**

Analysis of the case studies revealed the failure within the initial set of project attributes to account for the influence of variations in the level of management capability. Contrasts were identified in the levels of management capability in examples such as the passivent and the roof insulation material case studies. Within the passivent case study, the observation was made that management enjoyed previous experience of implementing the innovation within other projects. In addition, they demonstrated experience both as a team and individually, in the implementation of other innovations within construction projects. The experience brought into the project of both these aspects, provided management with a high level of capability for managing the innovation process. This contrasts with the roof insulation material case study, where none of the management team had practical experience of the innovation and demonstrated little experience of the management of innovation in other projects. The passivent case study experienced a higher level of management capability for managing both the innovation and the innovation process within the context of the project environment than represented in the roof insulation case study.

Within case studies of low levels of management capability, the evidence showed a need to increase these levels through facilitation. Case study (3), for example, placed considerable emphasis on the facilitation of their low level of capability, using workshops and visits to other project examples in order to raise their level of experience of the concept and its implications. As a result, potential limitations caused by a low level of capability were largely overcome. This contrasts with case study (2), which enjoyed similarly low levels of management capability, but failed to facilitate this in the same manner. The problems observed within this case study relating to the lack of understanding, can be attributed in part to this lack of facilitation, as the team's inexperience with both the concept and the needs of its management resulted in this being overlooked. The identification of this attribute allows for consideration of the influence and facilitation implications of variations in the nature of the management capability. Figure 9.2 includes the attribute of management capability, and the level identified within each case study is indicated as either high or low.

9.3.2 Facilitation requirements for each attribute

The 22 management success factors outlined in section 9.2 provide a generic set of factors requiring consideration within every example of the management of the innovation process within this context. Analysis of the differing form of each attribute revealed a contrast in the significance of the facilitation requirements for each. The form of the individual attributes determines which of the success factors are required for additional levels of facilitation. This was consistent with the observations made in chapter 7 regarding the varying significance levels associated with the contrasting requirements of managing the different types of innovation within each of the phases of the research model. This sub- section aims to outline an understanding of the influence observed for the differing forms of each attribute, identifying which of the 22 success factors requires additional levels of facilitation. The identification of these factors will allow management to develop a practical understanding for the facilitation needs of managing the process.

Innovation attributes

- **Type of innovation**

Chapter 7 discussed at length the implications for managing different types of innovation in relation to both the structural and management requirements of the research model. The definitions outlined in chapter 3, regarding the three types of innovation (i.e. system, process and component), were supported during the analysis of the case studies. The contrasting relationships between the integration of the innovation and project processes was reflected in the varying nature of the significance levels observed for the management activities of the individual phases of the research model. This discussion aims to take an overall view of the influence of the attribute of type, and consider the success factors requiring additional levels of facilitation.

The contrast between the hierarchy of governance observed between innovation and project processes for the three types of innovation was shown within the analysis to have implications on the approach taken by those managing the process. Those managing system innovations, such as within case study (3), were identified to reflect a top- down approach to management, with top- level management focusing on the percolation of the innovation into the individual projects. The considerations observed related to the need for effective leadership of the concept towards the receiving audience. In this example, the client body achieved this by setting out a clear structure for the implementation of the innovation within the projects, and the outlining of a series of strategies for engaging the project team in the process. Examples of this were provided through workshops, meetings and seminars geared at aiding both the understanding and participation of project team members with the innovation concept and its implications. The client body were conscious of the need to sell the concept to the project team in order to gain their acceptance for its use.

The experience of managing case study (3) contrasts heavily with that of the component innovation grass roof case study. The management of the component innovation reflected a bottom- up approach to management, with those managing the innovation focusing on achievement of its integration as an element of the wider project. The grass roof case study provides an example where those managing the innovation were required to ensure that the objectives of the innovation are aligned and beneficial towards the wider project. This reflects the governing nature of the project over the innovation, with the decision- making power relating to its inclusion residing with the project team, as opposed to those managing the innovation. This is the opposite when compared to the relationship observed in case study (3) and this reflects the contrasting nature of the management approach taken within each. The grass roof case study demonstrated a management focused on making the case for the inclusion of the innovation, by ensuring that its feasibility and suitability is presented and evident to the decision- makers. This is essentially selling the concept, but of a different nature to that of the system innovation due to the contrast in the governance between the processes.

Analysis of the process innovation case studies highlighted a need for considering a mixture of top- down and bottom- up approaches. This reflects the interdependent alignment of the integration of the innovation and project processes. Assessment of the wind turbine case study revealed a management response illustrating examples of both approaches. Examples of the sale of the concept to the remainder of the team from top-level management through the use of workshops and seminars (top- down), existed simultaneously with the presentation of suggestions to top- level management from the contractors working on the site (bottom- up).

Analysis revealed that the contrasting levels of success observed in managing the requirements of the different types of innovation was determined by the ability of management to recognise and understand the nature of the integration between the innovation and the project processes. Evidence illustrated that when management understood the requirements for achieving effective integration, they were able to tailor their response by adopting an appropriate approach. Assessing the contrast between the approach taken and resultant experience of managing the innovation process within case study (3) and (2) highlights this. These case studies were both system innovations and share almost an identical set of attributes (as seen in figure 9.2). However, whereas case study (3) achieved relative success in integrating the innovation within each of its individual projects, a contrasting failure was observed within case study (2). The client base within case study (3) was very visible and active in their leadership of the innovation, displaying considerable direction and control over the process throughout. Emphasis was placed in this example on facilitating the knowledge base of the team concerning the practical implications of using the innovation. Therefore, the team accepted and engaged with the innovation throughout the process. This contrasts heavily with case study (2) where a lack of recognition by management of the importance of providing top- level leadership and direction, resulted in a process that was not focused and uncontrolled. Indeed, it was apparent to many within the project team that top- level management did not believe in the use of the innovation, and had very little knowledge of its implications. As a result, a lack of understanding throughout the team for the implications of the innovation, and a lack of cultural preparation for receiving the innovation, resulted in a process that was abandoned during implementation in all but name.

The case studies revealed that the significance of the generic management success factors identified in the previous section varied depending on the type of innovation. Two levels of assessment was conducted between each of the case studies, comparison of those of the same type, and a comparison across the three types, in order to identify the success factors of greatest need for additional facilitation specific for each type. The research observed that whilst the satisfaction of every success factor is required for successful management of the innovation process, it was noted that the different types require additional emphasis to be placed on certain success factors due to the form of the attribute.

Figure 9.3 and 9.4 display the success factors targeted for additional management facilitation for the system and component innovation types respectively. The aim is that these tables will provide a practitioner with an indication of the success factors to place effort towards managing in order to achieve a successful integration of the innovation and project processes. Assessment of the nature of the factors identified illustrates that for system innovations (9.3) the factors are reflective of the

No. success factor	Success factors
6	Top- level participation (providing leadership and control)
10	Facilitate communication and information pathways (listening culture)
12	Selection of a facilitating team
13	Ensure sufficient lead in time and resource allocation
14	Provide management support system
20	Continuity and stability of the team

Figure 9.3: Key success factors for managing system innovations

No. success factor	Success factors
5	Integration of the cultural needs of the team (team level)
9	Ensure monitoring of the process
15	Develop and provide, technical and financial assessment

Figure 9.4: Key success factors for managing component innovations

top- down nature of the management process, and focuses on requirements for providing effective leadership and control, and the facilitation of the interaction of the remainder of the team with the concept. These factors are consistent with the observations made regarding the contrasting performances of case studies (2) and (3). The component innovation (9.4) on the other hand illustrates the need for additional facilitation of the more procedural aspects of the process, as the management requires to prepare a case for convincing the top- level management of the project of the justification for adopting the innovation. This is reflective of the bottom- up nature of the process. During analysis, it was observed that in relation to the process innovation type, none of the generic success factors were identified to be of greater significance than another, and were deemed equal. This reflects the equal reliance of the process innovation on both the top- down and bottom- up approaches of management. As a result, no table was produced, as managers require to consider all of the 22 success factors in figure 9.1. Through the generation of these tables, it is anticipated that practitioners may find it easier to target the management of the success factors in a manner that is reflective of the requirements of the attribute.

- **Source of the innovation**

Chapter 3 outlined the potential influence that the source of the innovation could have on the management of the innovation process, suggesting that there may be differing requirements for facilitating this process. It was anticipated that the origin of the innovation would determine the cultural reaction of the team towards its use. This section contrasts the experiences of managing the two forms of this attribute (i.e. internally generated and imported from an external source), and identifies the management success factors requiring additional levels of facilitation for each.

The analysis observed a tension within some of the poorly performing case studies relating to the source of the innovation (i.e. its origin). Within these case studies, it was noted that within the project team there existed a feeling that the innovation had been forced on them. Case studies (1) and (2) (imported innovations) highlight a problem associated with this concern, as many within the team felt the innovation had been forced on them from external sources due to the influence of the funding regime, causing resentment, as they were obligated to use the innovation whether they liked it or not. As a result, the team developed poor levels of ownership for the concept and viewed involvement with it as an activity of necessity, as opposed to desire. This was a problem noted within case studies representing both internally generated and imported innovations. Analysis of the demolition waste case study (an internally generated innovation) revealed similar feelings of resentment within sections of the team. The contractor within this example felt that the client and the consultant were forcing the innovation on the situation, without fully consulting the remainder of the team and assessing fully the alternative methods available.

Examples of such concerns were not noted within case studies identified as being relatively successful, such as case study (3) (imported innovation) or grass roof (externally generated). Analysis of both these case studies revealed that feelings of resentment were avoided by engaging the entire team in the process, and thus avoiding feelings of exclusion from the decision- making process and the perception of being forced. Contrasting the success of these case studies with those of poor performance revealed that they avoided the problem of creating an inner and an outer group within the team. Case study (3) for example demonstrates the use of strategies such as workshops, additional meetings, and seminars in order to achieve the involvement and understanding of the entire team in the process. This type of intervention was noted to be absent within case study (2) and as a result there was a failure to include the outer team in both the decision- making and the understanding of the process.

Analysis revealed that successful management of the innovation was achieved by integrating the entire team into the process. This was observed to aid in avoiding problems associated with team members feeling that the innovation was imposed and forced on them due to their exclusion from the process. Further investigation revealed that although this was the objective for all the case studies, the nature of the management response for facilitating this problem differed depending on the source of the innovation, i.e. whether it was internally generated or imported from an external source. Hence, there is a requirement to understand how management aim to facilitate this objective within the differing contexts presented by the source of the innovation. These differences were found during the analysis to reflect the slight distinctions noted in the cultural reaction to innovation depending on whether the source was internally generated or imported from an external source.

Internally generated innovations were observed to be more reliant on achieving the inclusion of the entire team in the creativity aspect of the process. Examples of successful case studies, such as the reed bed case study, placed considerable emphasis on ensuring that a culture was established across the entire team that facilitated the emergence of ideas and supported the innovation. Within this example, top- level management recognised the significance of internally generating innovations for achieving a competitive advantage over their competitors. Over the years, they had learnt to value the advantages gained by including the entire team in this aspect of the innovation process, by benefiting from everyone's contribution in the generation of the idea, but also by developing a sense of cultural ownership throughout the team for the innovation throughout. Examples such as the demolition waste case study did not place such a high emphasis on the need to include the entire team in this aspect of the process. As a result, an inner and an outer team were created, with low levels of ownership observed within the outer team. This lead to a perception that the concept was being forced on them by the inner group. The reed bed case study avoided this problem, as the entire team due to their involvement in the process from its inception, experienced a great deal of ownership towards the concept.

Imported innovations from external sources were found to require less of an emphasis on support for the creativity aspect of the process, and more on ensuring the suitability of the innovation for the project. Analysis indicated that internally generated innovations, such as the reed bed case study, require less emphasis to be placed on aspects of suitability, as the innovation had been created to the specification of a particular problem or situation. The imported innovation, on the other hand, has been created in another context external to the project, and may require to be adapted to ensure its suitability.

Case study (2) provides an example of an imported innovation that was adopted as a concept in practice without being adequately assessed for its suitability for the context. The client decided that a particular style of contract (PPC2000) for partnering was to be used in this case study. The contract was a template developed in other projects, and the success of these examples convinced the client of the benefits of its use. However, in reality, the practical implementation of the innovation proved to be inappropriate for the nature of the project. A failure of the client to engage with the remainder of the team resulted in a lack of awareness of the feelings of the team regarding the unsuitable nature of this concept for the needs of the project. The passivent case study, by contrast, demonstrates an example where management were able to make an effective decision regarding the termination of the innovation process due to its lack of suitability for the project. This example demonstrated the value of engaging with the remainder of the team, and making objective judgements on the suitability of the imported innovation.

Comparison of the case studies revealed that imported innovations initially receive a greater level of acceptance from a team than the internally generated innovation. The grass roof case study shows a project team that were happy to engage with the innovation's concept on the basis that they could visually see and assess it in its use within other projects. This is not an aspect that is possible for internally generated innovations, and represents the lower level of risk that is perceived by a project team when they can assess past experiences of using the concept. However, further investigation revealed that although imported innovations were perceived initially as less of a risk, over the longer term they prove more difficult to establish the same levels of ownership for the concept within the team.

Successful examples of internally generated case studies such as the reed bed case study, achieved successful facilitation through the support provided culturally by the entire team towards the process. They all felt empowered and involved in the process partly due to the effective facilitation of these aspects by the top- level management, but also through the recognition by the team of the innovation as their own. Whilst it is possible to achieve feelings of empowerment and involvement for imported innovations through management facilitation, evidence suggested that it was difficult to achieve the same levels of ownership for the concept. The grass roof case study presented a relatively successful example of management of the innovation process, however the levels of ownership within the team, whilst not negative in any way, were not as high as for the reed bed case study. Evidence suggested that involving the entire team in the identification and selection of the imported innovation can aid the facilitation of this issue and forge good levels of ownership for the concept, as was demonstrated in the grass roof case study.

Team members holding feelings of resentment over being forced to use an innovation in that they feel is unsuitably or unnecessary, has the potential to damage the management of the innovation process. The case studies showed that avoiding splitting the team into an inner and an outer team, can begin to overcome these problems through the empowerment and involvement of the entire team in the process, regardless of its source. However, the research observed that the nature of the management facilitation of this aspect requires to be sensitive to the differences between the forms of the attribute. Figure 9.5 (internally generated) and figure 9.6 (imported externally) outline the success factors identified during the analysis as requiring additional levels of management. Figure 9.5 places emphasis on encouraging the creation of a creative environment for the generation of ideas, and the basis for ensuring its viability in practice. Figure 9.6 on the other hand, emphasises the need for ensuring the suitability of the concept for the practical realities of the project, in addition to creating an environment that allows team members to develop a sense of ownership of the concept.

No. success factor	Success factors
3	Engagement with industry/ government agenda's- regulation and external environment
4	Ensure project standards are met
8	Fully consider research and experience of others (internal and externally)
15	Develop and provide, technical and financial assessment
19	Creativity and problem- solving culture

Figure 9.5: Key success factors for managing internally generated innovations

- **Complexity**

Complexity is defined within the research as an attribute that represents the nature of the linkages between the innovation and project, and the level of difficulty this presents to management in achieving the effective integration of the innovation within the project. The level of complexity was observed during analysis to be an influence on the requirements for managing the innovation process. The re- evaluation of the attribute of scale to reflect complexity was the result of recognition that it was the level of complexity that the innovation presents during integration within the project environment, and not its scale of novelty, that presented a challenge for management. This section aims to outline the contrasting management requirements for providing additional levels of facilitation for both high and low levels of complexity.

No. success factor	Success factors
1	Ensure and facilitate the integration of the aims/ objectives of the project with those of the innovation (project level)
2	The establishment of an innovation culture/ methodology
5	Integration of the needs of the team- (team level)
7	Ensure access and involvement provided to the entire team
14	Provide management support system
16	Create, acceptance and understanding
17	Participation and involvement
18	Proactive innovation culture
21	Team relationships

Figure 9.6: Key success factors for managing imported innovations from external sources

Assessment of examples such as the passivent case study illustrates the impact that a high level of complexity has on the management of the innovation process. As a concept, the proposed passivent system was familiar to many within the team, with some having practical experience of in previous projects. Technologically it represented a small advancement on standard methods of ventilation commonly available on the market, and was felt by team members to be easy enough to understand and therefore consider. However, due to the novel nature of other elements of the project, such as the grass roof, within the design, a great deal of uncertainty emerged regarding the integration of many of the components within the design. After a high level of consultation amongst the team, it was decided that the use of the passivent system presented an unsuitable level of added complexity to the design. For example, the innovation required vents to be placed in the roof, which in a traditional roof design would not have presented a problem. However, in this case, a great deal of uncertainty existed relating to the use of a grass roof, and the added complication of accommodating these vents within the specifications of the roof was deemed to present too high a risk. Therefore, the passivent system was replaced by a more traditional method that integrated more effectively with the other components of the design. Whilst the innovation was a failure in terms of achieving its implementation in the project, the management of the innovation process was deemed successful, as the team were able to effectively assess the integration needs of the innovation within the project, and recognise the unsuitable nature of its use.

Evidence from the case studies suggested that high levels of complexity, although presenting difficulty for managing the innovation process and its integration with the project, can be effectively overcome through appropriate management. A comparison between the management of the reed bed and recycled demolition waste case studies highlights this. Both demonstrated innovations of high complexity and both emerged as presenting solutions to specific complex problems. However, the experience of managing the integration of the innovation within the project differed with the reed bed case study adopting many strategies to overcome the problems associated with high level of complexity, and the demolition waste case study failing to engage with these needs.

Within the reed bed case study management were able to facilitate a cultural environment that allowed team members to develop a high level of involvement and ownership for the innovation as a concept. This helped to provide a degree of acceptance for its use, creating an environment where team members wanted to develop their knowledge base regarding the implications of the innovation process. Management within this example recognised the significance in overcoming the problems of high complexity by providing the team with the knowledge base to allow them to recognise the integration needs and overcome these problems. They identified that to achieve this, there was a need to create both a strong cultural environment within the team that is supportive of the innovation concept and its process, and to provide a structure that allowed the team access to information in order that they can develop their knowledge base. A series of workshops, seminars and additional meetings were structured throughout the innovation process. These had the specific function of both developing the knowledge base within the team regarding the innovation, and to enable management to gain from the contribution offered by the entire team. This example provided evidence of the valuable contribution that the entire project team can make when overcoming the complex obstacles presented in the integration of the innovation within the project.

The management of the demolition waste case study, in contrast, failed to overcome the high level of complexity presented by integrating the innovation within the project.

Although technically the innovation could be deemed a success at handover, the project was over budget and 6 months over schedule due to many mistakes. The root of these mistakes can be traced to a lack of knowledge throughout the team regarding the implications of the innovation, and a lack of desire of many members to develop their knowledge base in order to assist the process. As a result, the high level of complexity produced many mistakes and aided a culture that was destructive to the process rather than facilitating it. The benefits observed in the reed bed case study, relating to a facilitating culture where the team wanted to learn and improve throughout the process, was lost as a blame culture took root. Team members dealing with complex issues did not want to share knowledge in case they were blamed for the repercussions that it may have on the process. Although at first top- level management structured many opportunities for the team to aid their knowledge base through the use of workshops and additional meetings, the cultural foundations within the team for wanting to develop were not in place. The biggest problem, was the creation of an inner and outer team, with the outer team feeling excluded from the process. This resulted in a great deal of resentment towards the process. The inner team were relying heavily on the knowledge base of the outer team to overcome many of the technical issues of integration, but due to the cultural barriers they were unable to benefit fully from their contribution. Management intervention at the start of the project, to aid the creation of a culture supportive of the innovation across the entire team would have provided a far greater opportunity to overcome the difficulties of high complexity, through the utilisation of the knowledge base of the entire team.

Assessment of the case studies identified that it is not only high levels of complexity that need to be facilitated during management, but also lower levels. Within case study

(1) management felt at an early point that the team understood their role (a sufficient level of knowledge of how they individually were to interact with the innovation) within the innovation process. They perceived the level of complexity to be of a sufficiently low level that they withdrew almost entirely from the process during its implementation phase, and delegated responsibility to those further down the project hierarchy. This proved to be a mistake as management lost control of both the direction and the needs of the innovation. The scale of the complexity of the innovation, although low in contrast to other case studies, proved to be too much for those implementing it. Without effective management of the innovation process during the implementation phase, periods of project crisis presented the team with the opportunity to revert to traditional practices and to ignore the innovation. The research shows that the level of complexity requires to be mitigated with management of the team's knowledge base and an understanding of the implications of the innovation in practice. Although prior to implementation the knowledge base of the team was perceived to be sufficient, there was a requirement for management to monitor and facilitate these levels during implementation. Case study (3) provides an example of a similar innovation that was effectively managed throughout the process by continued leadership and monitoring by top- level management. This ensured that the knowledge base of the team was sufficient to engage with the difficulties presented during integration. Evidence showed that once individuals understand what is expected of their role within the process, and how this relates to the wider process, the scale of complexity can be effectively managed.

Figure 9.7 outlines the key success factors requiring additional effort for managing high levels of complexity. The focus of these factors is geared to supporting both the knowledge base of the team, but also by providing the cultural facilitation for aiding the team's ability to absorb and seek knowledge. Figure 9.8 outlines factors connected to the role of management in providing leadership and monitoring the interaction of the team with the integration. The need to maintain control of the process by maintaining a gauge on the knowledge base of the team, despite the low level of complexity, was identified as key to ensuring success.

Project attributes

- **Management style**

Chapter 3 identified a need to assess if the style of managing the project influenced the requirements for managing the innovation process. Two forms of this attribute were observed, those managed as an in- house project within an established organisation, and those managed within a multi- party project with a temporary lifespan. This section aims to outline the contrasting levels of facilitation required by these different management environments, and outlines the success factors requiring additional management for the multi- party project environment in order for it to create a environment supportive of innovation.

A comparison of case studies of the two styles shows an obvious advantage provided by managing innovation within an in- house project environment. The three case studies from the sample were subjectively assessed as being the most successful in managing the innovation process were all in- house projects (roof insulation material, reed bed, and the wind turbine case studies). Studying the case studies revealed that it was not so much the style of management, but that the environment for managing innovation provided better foundations for satisfying the success factors identified previously in this chapter.

No. success factor	Success factors
7	Ensure access and involvement provided to the entire team
8	Develop the knowledge base
11	Clearly define roles and responsibilities
13	Ensure sufficient lead in time and resource allocation
14	Provide management support system
16	Create, acceptance and understanding
17	Participation and involvement
21	Team relationships
22	Project performance

Figure 9.7: Key success factors for managing high complexity

No. success factor	Success factors
6	Top- level participation (providing leadership and control)
9	Ensure monitoring of the process
10	Facilitation communication and information pathways (listening culture)

Figure 9.8: Key success factors for managing low complexity

The in- house project environment, due to its organisational context, provides the innovation process with a cultural environment where the team enjoys a shared set of goals and values. The wind turbine case study illustrates the benefits for managing the innovation process within an environment where the team operate in both a culture and structure that is established and understood by all its members. The entire team belonged to an organisation that placed considerable value on discovering and developing innovations, and a mutual recognition exists of the benefits that innovation brings to the individual through the success it provides for the organisation. The organisation, due to its manufacturing roots, placed considerable emphasis on facilitating creative thinking, and developing a culture where innovative ideas where regarded as an opportunity, as opposed to simply being dismissed out of hand. The wind turbine concept emerged out of a period of creative thinking within a meeting, and the idea was sufficiently supported by team members to enable its feasibility to be properly assessed. A cultural openness within the team was based firmly on factors such as trust, and the recognition that everyone was aiming to achieve a shared goal of improvement. This provided a facilitating environment for idea generation. The established nature of the relationships between team members aided their trust of each other and the quality of the communication pathways that existed between them. This was demonstrated when the project manager was able to secure permission to pursue the concept from the factory manager on the basis that the factory manager trusted the judgement of his project manager. Initial funds were released, based on the quality of their relationship, and the factory manager's confidence in the judgement of one of his team, due to their experience. The reed bed and the roof insulation case studies also displayed these qualities, and management were able to provide a background that was culturally supportive of the innovation and its needs. These are qualities difficult to achieve naturally in the temporary multi- party environment, as there is a lack of a shared history between team members, and no shared culture.

In addition to the cultural support that exists within the in- house project, a recognised structure for management was utilised within all three of the case studies. This structure followed the traditional project management methodologies adopted within any project that an organisation pursues. The wind turbine case study provided an example of the use of such an approach for structuring the management of the innovation process. The main advantage that this presents is that a rigorous and proven method is deployed, that everyone within the team has previous experience of and understands. The established nature of the process provides the team with a degree of confidence that an innovation will be considered and supported fully until its feasibility and suitability for the project has been assessed as inappropriate. Within this example, team members who were sceptical of the practical implications of the innovation were prepared to support the innovation process despite their concerns, as they had confidence in its rigorous nature. The adoption of an established structure resulted in a team who understood their role within the process, in addition to ensuring that the entire team was provided the access and the levels of involvement required for facilitation.

Analysis of all three of the in- house organisational case studies revealed that they each had a positive environment within which to manage innovation. It is logical to suggest that not all in- house projects will provide such a positive environment for managing the innovation process, as examples of poor management exists. However, it is apparent when compared to the multi- party project environment that in- house potentially pose better foundations from which to facilitate the management of the innovation process due to the established nature of both their structure and culture.

An assessment of examples such as case study (1) provides evidence that the temporary nature of the multi- party project does not possess such established qualities its. The team selected was not able to draw on any established, shared experiences of working with each other, and the relationships were fresh. The client representative recognised, from an early point within the process, the need to facilitate the relationships between team members, to enable them to develop feelings of trust and communication pathways. In this case, facilitation failed to achieve this goal, due to the largely short-term focus of many of the team members. The contractor viewed the project as having a limited lifecycle and questioned the value of the innovation to their organisation beyond the end of the project. This highlights the hostility that many presented towards innovation, due to the short- term focus encouraged by the temporary nature of the project environment, and the perceived lack of value associated with the risks involved in innovating. In- house projects such as the wind turbine case study demonstrated a culture where the risk associated with pursuing an innovation was deemed acceptable to the long- term future of the organisation. Across the interviews, it was observed that within multi- party projects, due to their temporary nature, it was difficult to recognise what the long- term benefits were to justify the investment of the time and resources required. Within examples such as case study (1), many regarded the innovation as inappropriate for use within the project, and when the opportunity emerged, through a lack of leadership from the client for the team to adopt a traditional approach, the innovation was rejected.

In addition to the lack of cultural facilitation towards innovation (due the temporary nature of this environment), there existed a lack of an established structure for managing the innovation process that is understood within the team. The wind turbine case study demonstrates an example where team members could join any project within the organisation and expect to find the same management methodology in operation. The multi- party project environment, due to its temporary nature, finds team members joining who are unfamiliar with the methodologies adopted for managing such processes. In case study (2), this unfamiliarity with the way of managing the process produced confusion between team members, and uncertainty in the effectiveness of the approach taken. The contractor, for example, had a very different management approach to the client base, and it proved difficult for many members of the contractor's organisation to adjust to the team orientated approach favoured by the client. This placed pressures on the process, as the contractor failed to adapt to the approach taken by the client, resulting in serious communication problems and a breakdown in the quality of the relationship between these groups. The lack of an established structure for the team to interact with the management of the process results in team members being required to learn and adjust to the requirements of the chosen methodology for the process. Within case study (2), this resulted in mistakes and misunderstandings throughout, a situation that was not helped by the lack of explanation or communication relating to the implication of the concept from the client, to aid the interaction of the team with the process. An inability or lack of desire to interact with the management methodology adopted, was identified within this case study to result in team members failing to interact with the aims and needs of the concept itself. This problem persisted to the extent that during periods of project crisis, these team members quickly rejected the innovation as the approach to solve the problem, resulting in the contractor attempting to steer the project away from.

Two multi- party case studies were able to overcome many of the cultural and structural problems relating to managing innovation within a temporary project environment, by placing considerable emphasis on facilitation. Within both the grass roof case study and case study (3) the client representative set about facilitating the environment in a manner that reflected many of the qualities found in the in- house projects. The client base within both of these case studies recognised the cultural need to create an atmosphere within a temporary project that encouraged a shared vision and goal within the team. They understood the benefits that are achieved through the establishment of strong relationships between team members, aiding both the levels of trust and the quality of the communication pathways. As a result, within both case studies, the teams were selected based on a previous working relationship. This was implemented in the hope that team members would view the opportunity of working with the client as the basis for the long- term. The selection of a team that had already worked together brought a familiarity in the nature of both the structural working practices of the client, and provided a series of established relationships aiding both communication, and but confidence and trust levels in each other. In addition, emphasis was placed after selection in facilitating these relationships with workshops and additional meetings to reduce the levels of uncertainty existing within the team about both the concept and each other. Management placed considerable effort on team selection, but followed it through the process to ensure that the team were able to develop a shared vision for the project that was innovative in its thinking. Although both of these case studies represented different types of innovation, the approach to the facilitation of the project environment was similar, and was driven by the aim of achieving an environment that was reflective of an in- house organisation.

The client base of these case studies also recognised the need for a structure to be developed at the beginning of the process for its management that was easy to understand and interact with. The client representative spent time outlining the management structures for both the innovation and the remainder of the aspects of the project though workshops, and monitored the levels of understanding within the team throughout the process. Aware of the problems that the lack of an established structure familiar to a team can present, the selection of a team with an established working relationship made this less of an issue in these case studies. However, it remained important to aid the team's understanding of the methodology, to lessen problems caused through confusion, by establishing it at the beginning of the project. Establishing the methodology at the beginning of the process allows a more organisational feel to emerge regarding the structure. This aspect was lost in case study

(2) where the team remained confused as to how to interact with the structure of the process throughout the project.

It is apparent that management requires to be aware of the additional facilitation requirements of the multi- party project during the innovation process, and to actively facilitate these projects in a manner that allows them to behave more like an in- house organisation, through the removal of the cultural and structural problems associated with its temporary nature. Figure 9.9 outlines the key success factors requiring additional management effort for multi- party projects, in order that they achieve a culture and structure more reflective of an in- house project. This observation ties with the calls of Winch (2000) for construction projects to adopt a more organisational approach both structurally and culturally, and with Gann's (2000) call for the mitigation of the negative effects of the temporary nature of the project environment, in order to achieve an improvement in innovation.

- **Funding regime**

Chapter 3 identified the need to assess the potential influence that the differing nature of the projects funding regime has on the management of the innovation process. The two forms of the attribute outlined are of projects funded through either public or private sources. This section aims to present the distinctions of managing the innovation process within these different environments, and outlines the management success factors required for each.

Comparison of the case studies revealed that the three projects deemed subjectively as the most successful in managing the innovation process were those that received private

No. success factor	Success factors
2	The establishment of an innovation culture/ methodology
5	Integration of the cultural needs of the team- (team level)
7	Ensure access and involvement provided to the entire team
12	Selection of a facilitating team
16	Create, acceptance and understanding
17	Participation and involvement
18	Proactive innovation culture
19	Creativity and problem- solving culture
21	Team relationships

Figure 9.9: Key success factors for managing innovation in multi party projects

sector funding (roof insulation material, reed bed gully waste and the wind turbine case studies). Assessment of these three case studies revealed that privately funded projects enjoy a better natural level of facilitation to managing the innovation process, by comparison to the publicly funded projects. The roof insulation case study was a component of a large housing development for sale to the private market. The entire project was managed in- house by a private organisation, for the purposes of making a profit. The development was aimed a high value sector of the market, with emphasis placed on aspects such as the quality of materials used. The innovation represented the inclusion of a new material for the insulation of roof spaces in houses, and was seen as state of the art technology for complying with expected changes in regulations. The architect decided that it would be possible to try out the innovative material within this project for the future benefit of others. He felt the initial cost of incorporating a new technology in the design could be offset due to the high value of the sale of the properties. The organisation shared the perspective of the architect and supported the innovation as a component of the project throughout, due to the recognised benefits they predicted for competitive advantage in future developments. This case study provides an example where private investment in an innovation is taken with a long-term perspective, with the view to achieving a competitive advantage. The investment in the process by the client was taken with an enlightened approach to innovation, as they saw the risk involved in the process as being calculated, and that the uncertainty involved in the process worthy of its consideration.

The reed bed case study provides an example of a project where a strong emphasis is placed on supporting the culture for creativity. The tolerance demonstrated by top-level management during the process of developing innovation within this project, highlights the shared levels of accountability encouraged within the team. The significance within the case study placed on developing for the long term, resulted in a management approach that steered away from a blame culture. Within these case studies, much of this culture was inherited from the in- house nature of the projects organisation, however it was apparent that the nature of the funding regime was a contributing factor behind the drive for financial success.

The need to ensure that the innovation was suitable, both with regard to its integration with the objectives of the project, and in terms of its feasibility as a concept was observed in the case studies. The reed bed case study provides an example where management were very conscious of providing a rigorous management process for ensuring the overall suitability of the innovation to the needs of the situation, whilst simultaneously maintaining a pro- innovation culture. Experience had taught them to exert control when managing innovation, as poor judgement can have financial repercussions for all parties.

An examination of the publicly funded case studies presented a very different picture. The case studies demonstrated a wide variety of different innovations, displaying a varied set of attributes. However, consistent across them was the influence of a culture of accountability that hinders the innovation process. Case study (1) provides an example of a council building project of the construction of a new high school, and implementation of partnering as an innovation for managing the different phases of the project. The level of public scrutiny received by the project from within the council, the local media and members of community placed considerable pressures on the team regarding every decision made. Conflict existing between the education department and the elected members over issues such as the cost of the project made the task of managing the project difficult, as every aspect was questioned. This can be positive for ensuring that decisions are well thought through, but in this case it created a stifling environment with a small margin of error. This resulted in the emergence of a short-term culture within the project team, which became directed by the needs of the project as opposed to the needs of the innovation. This placed considerable pressures on the innovation, as it was a system innovation. Although the elected council members were initially keen to be seen to be supportive of the use of partnering within a construction project, over time their concern became focused on ensuring that the project was on time and in budget as these were the primary the concerns of the general public. The client representative was unable to maintain the leadership of the concept within such an environment, and during phase 3 of the project, the innovation existed in name only as it was replaced in practice by a more traditional method. Within these circumstances, there is no room for taking a long-term perspective as the risk of failure acts a barrier, and the potential long- term benefits offer little attraction for the members of team.

Such an environment of accountability was reflected within many of the other case studies, where a justification of public funds is constantly required. Within examples such as the demolition waste case study, this level of scrutiny placed a great deal of pressure on the team to be successful. This kind of pressure brings a blame culture to the process of managing the innovation. This was a noticeable problem within this example, which affected the relationships between team members and as a result damaged the effectiveness of managing the innovation.

Analysis of the public sector case studies revealed that in specific circumstances the level of public scrutiny could also act as a facilitating factor to the consideration of innovation with projects. The agenda of the government and the industry can have a dominating influence in the promotion of innovations within the public sector. The grass roof case study provides an example of this, with the government pushing the use of environmentally sustainable innovations, and supporting it through a series of funding initiatives. During the interviews it was revealed that if the government had not provided specific funds for aiding the use of the innovation, then it would not have been considered. This was also a feature of other case studies, including the three system innovation case studies; however, it was apparent that despite being adopted under a positive atmosphere, the pressures associated with managing innovation within a publicly funded project negatively affected the management of the process in two of these examples.

The management of case study (3) demonstrated an example where management was able to overcome many of the pressures associated with public scrutiny. The client representative imposed a structure on the management of the process that retained the governance of the innovation over that of the project. This was significant as it protected the innovation during periods of project crisis, a feature that was not achieved within either case study (1) or (2). Culturally, provision was made to facilitate the relationships and knowledge base within the team, to ensure that concerns could be shared as opposed to being drawn into a blame culture. This was achieved through a range of techniques such as the use of workshops, and additional meetings, but by also aiming to create an open and inclusive environment throughout the process. Evidence also indicated that by communicating effectively with the wider stakeholders of the project regarding the objectives and implications of the innovation, the level of scrutiny became one of interest as opposed to accountability. This was a technique drawn on heavily within the grass roof case study to great success.

Management requires to understand that different funding regimes experience a contrasting set of influencing factors when managing the innovation process, reflective of the context that they are received. It is possible for a publicly funded project environment to support an effective innovation process in the manner of case study (3), however management have to recognise that it will be harder within this context than within the culturally innovation friendlier private sector. Figure 9.10 displays the key success factors identified as requiring additional management effort for publicly funded projects, highlighting the need for greater creativity and support for the innovation process within this environment, in order to mitigate the culture of accountability stifling innovation. Figure 9.11 displays the key success factors identified for additional management effort for privately funded projects, highlighting the need to maintain control and reduce the potential risk of managing innovation within privately funded projects.

- **Management capability**

As discussed previously in this chapter, the identification of the attribute of management capability as an influence on the management of the innovation process, allowed for consideration of the level of experience that management has with both the innovation and of managing the innovation process. Through comparisons of the case studies the need to assess how well equipped those managing the process are for achieving success became apparent. This discussion will outline the influence of both

No. success factor	Success factors
2	The establishment of an innovation culture/ methodology
18	Proactive innovation culture
19	Creativity and problem- solving culture
22	Project performance

Figure 9.10: Key factors for managing innovation in publicly funded projects

No. success factor	Success factors
5	Integration of the cultural needs of the team- (team level)
15	Develop and provide, technical and financial assessment

Figure 9.11: Key factors for managing innovation in privately funded projects

high and low levels of management capability, and present the key success factors requiring additional management effort.

Assessment revealed that six of the case studies began the innovation process with a low level of management capability. Examples such as the demolition waste case study highlighted the influence that low levels of management capability can have on the innovation process. Those managing this process displayed limited experience of the technical aspects of using recycled demolition waste as fill material, and consequently the knowledge base within the project was low. In addition, management demonstrated no real experience of managing innovation processes in previous projects. During the handover phase of the innovation process, it was concluded that the innovation was technically a success, but that in achieving this the project ended up over budget and late. Interviews revealed a feeling within the team that the lack of experience of management with both the specifics of the innovation, and in managing innovation's, resulted in a catalogue of mistakes that had both budget and timescale implications. The innovation process was effectively ran as a traditional project, due to being a process innovation. No provision was made within the structure of the project to facilitate the innovative nature of the project, with techniques such as the use of additional workshops, additional meetings and seminars geared towards developing the knowledge base of the team. The absence of these features, outside of those traditional within the structure of a construction project, stemmed from the lack of awareness within the client body that, due to the innovative nature of the project, additional facilitation would be required. Many within the team, such as the contractor, argued that the client's lack of experience in managing innovative projects had resulted in this problem. They felt that the mistakes that dogged the project throughout were a consequence of the lack of the management's technical understanding and familiarity with the innovation and its implications, a problem exacerbated by the failure to provide adequate management of the process.

The combination of these two aspects resulted in a management team that demonstrated a low level of capability towards the management of the innovation process. Comparison with the roof insulation case study illustrated that, although management can experience low levels of capability at the beginning of the process, the potential exists to raise the level of capability over the course of the process, through facilitation. Like the previous example, management displayed a low level of experience of both the technical implications of using the innovation, and of managing innovation processes. Contrasting the two examples however, revealed that by recognising and then aiming to address the deficiencies in the levels of capability, the problems experienced in the demolition waste case study can be overcome, and the levels of capability raised. The roof insulation case study provided an example where management, recognising that they had a knowledge gap with regard the technical implications of the innovation, and a degree of inexperience for managing such a process, sought to gain experience in both aspects from external sources. The architect spent time talking to the manufacturers of the insulation material, and arranged for the joiners fitting the material to meet with those currently implementing it in other projects. In addition, consultation took place with the regulator in order to gain advice and knowledge regarding the standards to be met. This provided an exchange of information relating to both the technical aspects of the innovation, but also regarding its management as a process. The architect reviewed both industry and academic research into the use of the material, to enhance his technical knowledge but also to ensure that the innovation was suitable for the requirements of the project. This was not possible internally within the team, as no one had the experience necessary, and as a result, the experience was sought externally.

The consequence of such an approach allowed the opportunity for the team to develop the knowledge base to the level that many of the mistakes and problems evident in the recycled demolition waste case study were avoided. These examples illustrate that it is important for those managing an innovation process to simply not accept their level of capability, but to recognise that it can be developed over the course of the process.

When assessing case studies demonstrating high levels of management capability, a contrast was observed between the effectiveness of management in taking advantage of the facilitation provided by these high levels. The passivent case study, although displaying an example of an innovation process that was terminated prior to implementation, provides an example of a management team with a high level of management capability, and the positive influence that this had on the process. The project team had both previous experiences with the implementation of the innovation within past projects, and of managing innovation processes (i.e. the grass roof). This allowed management the capability to assess that the innovation was no longer viable for the project during the formulation and development phase of the innovation process. An advanced level of knowledge regarding the innovation provided an understanding of the nature of its integration with the remainder of the process, and provided the basis for an assessment regarding its implications of the other components of the project's design. The experience that the team have of managing innovation processes provided them with the maturity to make an informed decision regarding the viability of implementing the innovation within the process. The client argued that without this level of experience, there may have been a temptation to continue with the innovation process due to a lack of awareness of the potential problems that implementation presented for the wider project.

Analysis revealed that high management capability levels are not a guarantee to achieving successful management of the innovation process. Case study (1) and (2) demonstrate examples where, despite a high level of capability being demonstrated at the start of the process, there was a failure to build on these foundations over the course of the process. The management of both enjoyed a base- level of knowledge of the innovation concept, and had previous experience of managing innovation processes. However, in both case studies this failed to stop the concept existing in practice in name only during the later stages of implementation. Management had failed to build and develop their initial high levels of capability regarding the management of the process. Within case study (1), the contractor suggested that due to the base level of knowledge possessed by management regarding the innovation concept, the client representative felt that he knew everything that he needed to know. The contractor argued that in this case, having a little knowledge acted as a barrier for the client in the search for more. The client within this example would have clearly benefited from gaining advice from external sources, attending workshops and seminars and doing background research on the implications of using the innovation. As a result, management felt it difficult to make informed decisions regarding the innovation, and finished the process with a low level of capability.

Figure 9.12 displays the key success factors identified as requiring additional management effort for low management capability. Consideration of the experiences of managing the innovation process revealed that apart from the demolition waste case study, all of the case studies displaying low management capability recognised the need to facilitate these success factors, and were relatively successful in raising their level of

No. success factor	Success factors
1	Ensure and facilitate the integration of the aims/ objectives of the project with those of the innovation (project level)
5	Integration of the cultural needs of the team- (team level)
6	Top- level participation (providing leadership and control)
8	Develop the knowledge base
10	Facilitate communication and information pathways (listening culture)
11	Clearly define roles and responsibilities
12	Selection of a facilitating team
13	Ensure sufficient lead in time and resource
16	Creative, acceptance and understanding
20	Continuity and stability of the team
21	Team relationships
22	Project performance

Figure 9.12: Key success factors for managing low levels of capability

capability over the course of the process. The identification within these case studies of their low levels of management capability appeared to provide management an incentive to improve. The analysis revealed the dangers within examples of high levels of management capability, of neglecting the need to continue to develop. Figure 9.13 identifies the key success factors requiring additional management effort in order that management continues to develop their capability throughout.

No. success factor	**Success factors**
2	The establishment of an innovation culture/ methodology
4	Ensure project standards are met
8	Develop the knowledge base

Figure 9.13: Key success factors for managing high levels of capability

9.3.3 The management facilitation grid

The previous section outlined the influence of the individual forms of both the innovation and project attributes on the management of the innovation process. Assessment of the case studies revealed the need to consider the influence of these attributes as a set, as opposed to focusing on them individually. Figure 9.2 displayed the form of each attribute for the individual case studies, illustrating the contrasting composition of each as a set. The form of each attribute requires a management response that targets an identified set of success factors for additional facilitation, as laid out in the previous section. Assessment of the case studies illustrates, that targeting the management response to facilitate the form of an individual attribute does not guarantee the successful facilitation of the process. The grass roof case study highlights an example where management targeted the facilitation of needs of its multi- party project environment. Whilst successful to a certain extent in creating a project culture that reflected an in- house project in its feel, the success of their intervention was limited because of the influence of the public sector nature of the project. This example highlighted the need for management to consider the management requirements for the process based on the form of the attributes as a set. This section aims to provide a tool to aid practitioners in the identification of the additional management requirements reflective of their particular context, based on the understanding of the form of the attributes as a set. The development of such a tool aims to allow management to tailor their response to the requirements of both the innovation and the project.

Figure 9.14 displays the management facilitation grid, displaying horizontally the 22 generic success factors outlined in section 9.2, and vertically the form of the individual attributes. The blackened boxes on the grid, display the success factors identified as requiring additional management relating to the form of the attribute. Figure 9.14 represents a complete grid, in that it displays all the success factors requiring additional levels of facilitation for the different forms of all of the attributes. Practitioners would use the grid to identify the success factors requiring additional management facilitation, for the relevant form of each attribute in the set. Figure 9.15 displays an example of a grid tailored for the roof insulation case study, identifying the success factors for the form of each of the attributes for this case study. Management can then use the grid, to identify the level of significance that each of the success factors represent to the overall

	Attributes		1. Project integration	2. Est. methodology	3. Engage with agenda	4. Project standards	5. Team integration	6. Top-level participation	7. Access and involvement	8. Knowledge base	9. Monitoring process	10. Communication	11. Defined roles	12. Select facilitating team	13. Lead-in time, resources	14. Support system	15. Feasibility assessment	16. Accept and understand	17. Participation culture	18. Proactive culture	19. Creativity culture	20. Continuity + stability	21. Team relationships	22. Project performance
Innovation	Type	System						■				■		■	■	■						■		
		Process																						
		Component					■				■						■							
	Source	Internal			■	■				■							■				■			
		External	■	■			■		■							■		■	■	■			■	
	Complexity	Low						■			■	■												
		High							■	■			■		■	■			■	■			■	■
Project	Capability	Low	■				■	■		■		■	■	■	■			■				■	■	■
		High		■		■				■														
	Funding Regime	Public		■																■	■			■
		Private					■										■							
	Management Style	In house																						
		Multi party		■			■		■					■				■	■	■	■		■	

Management success factor

■ Additional management facilitation required for success factor

Figure 9.14: Management facilitation grid

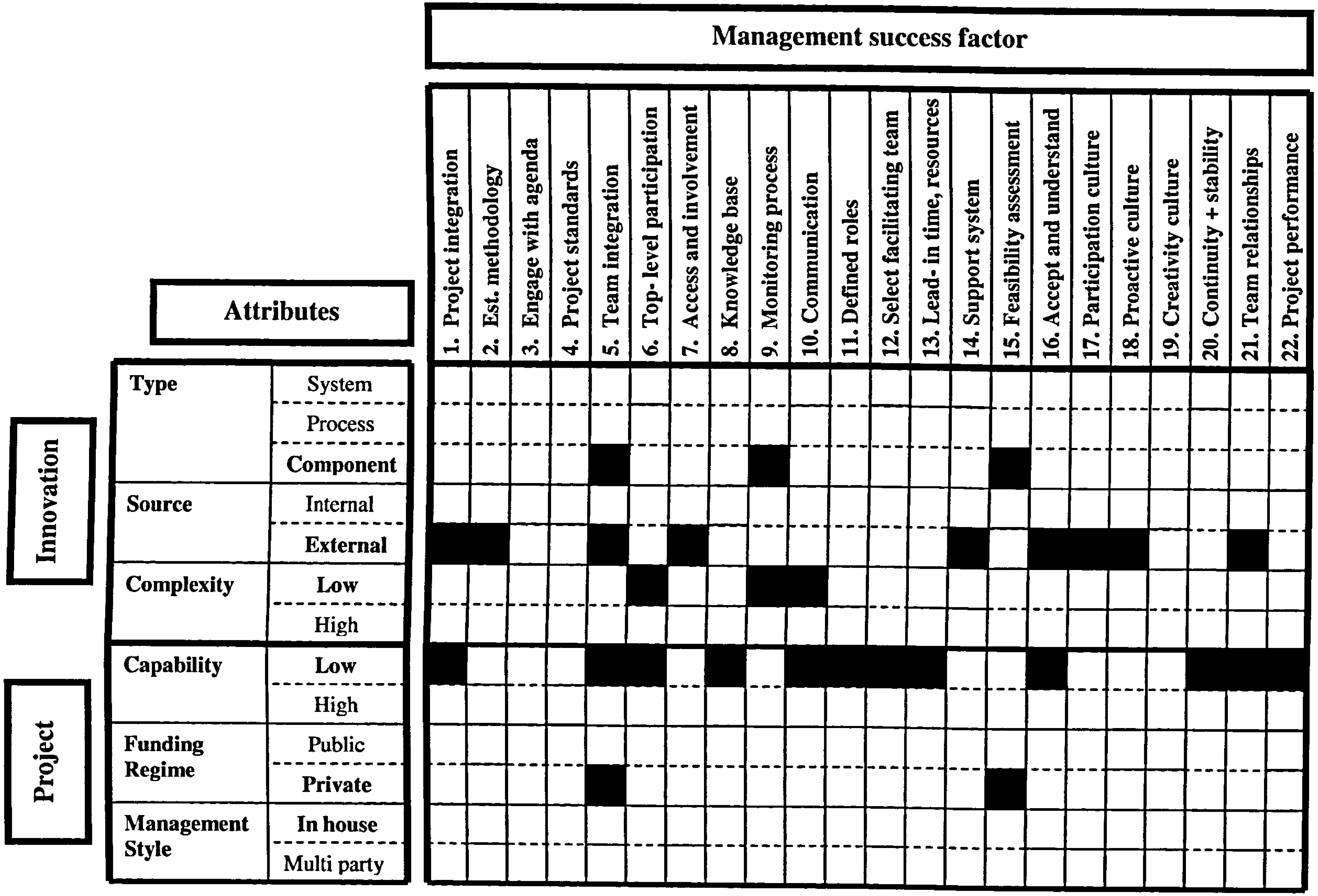
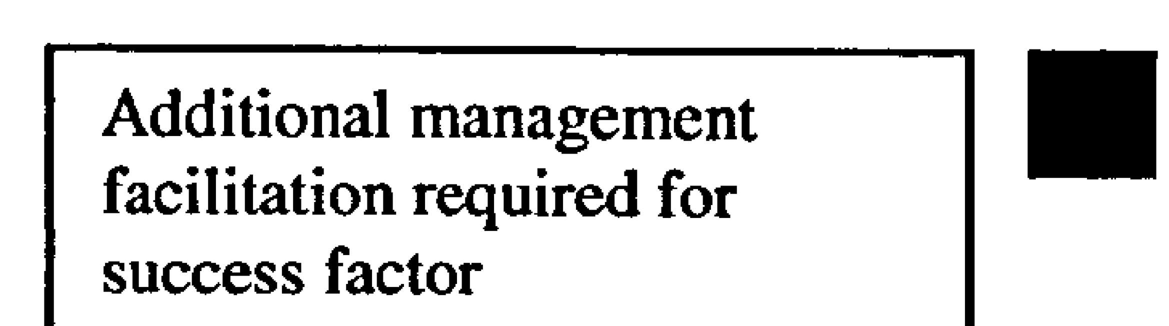


Figure 9.15: Management Facilitation Grid- roof insulation case study



facilitation of the innovation process. Within this case study for example, success factor No 5 (integration of the cultural needs of the team) was identified as requiring considerable emphasis on its facilitation, as it was identified as a requirement of the form of four of the attributes. Although all of the success factors require satisfaction, the grid guides management towards which of the factors require additional levels of facilitation, and allows an identification of the significance of the success factor due to the form of the attributes set.

The development of the management facilitation grid provides the opportunity within the research to assess the success factors requiring additional levels of facilitation, for each of the case studies in the same manner as in figure 9.15. Since the form of the attributes for each case study is identified in figure 9.2, it is possible to observe the facilitation requirements for each as a set. Figure 9.16 provides a table illustrating the number of times across the attribute set that each of the 22 success factors were identified in each of the case studies, as requiring additional management. For example, success factor No 5 (integration of the cultural needs of the team- team level) was identified in the roof insulation material case study as requiring additional facilitation as a factor for four of the six attributes. This identification provides the opportunity to assess individually the frequency that each of the individual success factors was identified as requiring additional levels of management facilitation across all of the case studies. This number is displayed as the significance of factor, and its comparison with the rest of the success factors, enables each to be ranked individually in order of significance (highest to lowest). For example, success factor No 5 was identified 24 times across the case studies as requiring additional levels of facilitation, and was identified as the third most significant factor. This table contributes to an understanding

	Management Success Factor																							
Case studies	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**Score**	**No. of Factors**
Roof Insulation Material	2	1	0	0	4	2	1	1	2	2	1	1	1	1	2	2	1	1	0	1	2	1	28	19
Reed Bed Gully Waste	1	0	1	1	2	1	1	3	0	1	2	1	2	1	3	1	1	1	1	1	2	2	28	20
Wind Turbines	2	1	0	0	3	1	2	2	0	1	2	1	2	2	1	2	2	2	0	1	3	2	32	18
Grass Roof	2	3	0	0	3	1	3	2	0	1	2	2	2	2	0	3	3	4	2	1	4	3	41	18
Case Study (3)	2	3	0	0	3	3	2	1	1	3	1	3	2	2	0	3	2	3	2	2	3	2	43	19
Passivent	1	4	0	1	3	0	3	2	1	0	1	1	1	2	1	2	3	4	2	0	3	2	38	18
Recycled Demolition	1	2	1	1	2	1	2	3	0	1	2	2	2	1	1	2	2	3	2	1	3	3	43	21
Case Study (2)	1	4	0	1	2	2	1	1	1	2	0	2	1	2	0	2	2	3	2	1	2	1	33	19
Case Study (1)	1	4	0	1	2	2	1	1	1	2	0	2	1	2	0	2	2	3	2	1	2	1	33	19
Significance of factor	13	22	2	5	24	13	16	16	6	13	11	15	14	15	8	19	28	24	13	9	24	17		
Factors Rank	14	5	22	21	3	13	8	9	20	15	17	10	12	11	19	6	1	4	16	18	2	7		

Figure 9.16: Success factors- level of facilitation

of the level of facilitation required to each of the success factors across the each of the case studies. The ranking produced allows for an identification of the most frequent factors requiring management intervention in order to facilitate there needs.

Figure 9.17 displays the five highest ranked success factors requiring additional facilitation across the case studies. The identification of these five factors ties closely with many of the key themes observed within the case studies relating to the need for developing the level of understanding and acceptance within the team for the innovation. Success factors No 5 targets these issues directly, with the other four (No 17, 21, 18 and 2) outlining methods for aiding its achievement. The grass roof case study represents an example where management recognised the need to facilitate the culture of the team to aid the understanding and acceptance of the concept. They linked the need to establish a group culture as a means of achieving involvement and participation within the process for the team, to the enhancement of both the knowledge base of the team and the awareness of the implications of the innovation. Management used a range of techniques within this example such as workshops, seminars and additional meetings to facilitate these success factors with the aim of creating a group culture within the team. The connection between these factors is evident throughout the case studies, and effective management significantly enhances the level of understanding and acceptance within the team for the innovation.

Figure 9.16 also provides the opportunity to assess the level of additional management for each of the case studies with two measures, the score: reflecting the total number times across the attribute set that success factors were identified as requiring facilitation, and the number of success factors: identified at least once as requiring additional levels

Ranking of success factor	Number of success factor	Success factor identified for additional facilitation
1	17	Participation and involvement
2	21	Team relationships
3	5	Integration of the cultural needs of the team- (team level)
4	18	Proactive innovation culture
5	2	The establishment of an innovation culture/ methodology

Figure 9.17: Five highest ranked success factors requiring additional management facilitation

of facilitation. These measures allow a comparison to be drawn between the case studies, and provide an indication of which requires the most additional management facilitation due to the form of its attribute set. Figure 9.15 displays the management facilitation grid for the roof insulation case study, which was observed in figure 9.16 as the case study with lowest score and one of the lower number of factors identified. As a result, it can be argued that due to the form of its attribute set, it enjoyed the highest level of natural facilitation of all the case studies, as it required the least amount of additional management facilitation. Figure 9.18 on the other hand, displays the management facilitation grid for the grass roof case study, and was observed in figure 9.16 as having a much higher score than the roof insulation case study. Based on this rational, this case study represents a lower level of natural facilitation towards the success factors, and therefore requires the higher levels of additional management facilitation.

Analysis of each of these case studies over the course of the process, reveals that whilst a lower score provides a higher level of natural facilitation, this does not guarantee success. The grass roof case study for example, despite its low level of natural facilitation when assessed subjectively, was identified as one of the more successful examples of managing the innovation process within the sample. This example can be compared to case studies (1) and (2), which enjoyed a higher level of natural facilitation, but were identified consistently throughout the thesis as the poorest examples of managing the innovation process. This contrast demonstrates that it is the role of management to understand and tailor the facilitation response to overcome a difficult set of attributes. The management facilitation grid provides management with the opportunity to be informed and understand the specific requirements for managing

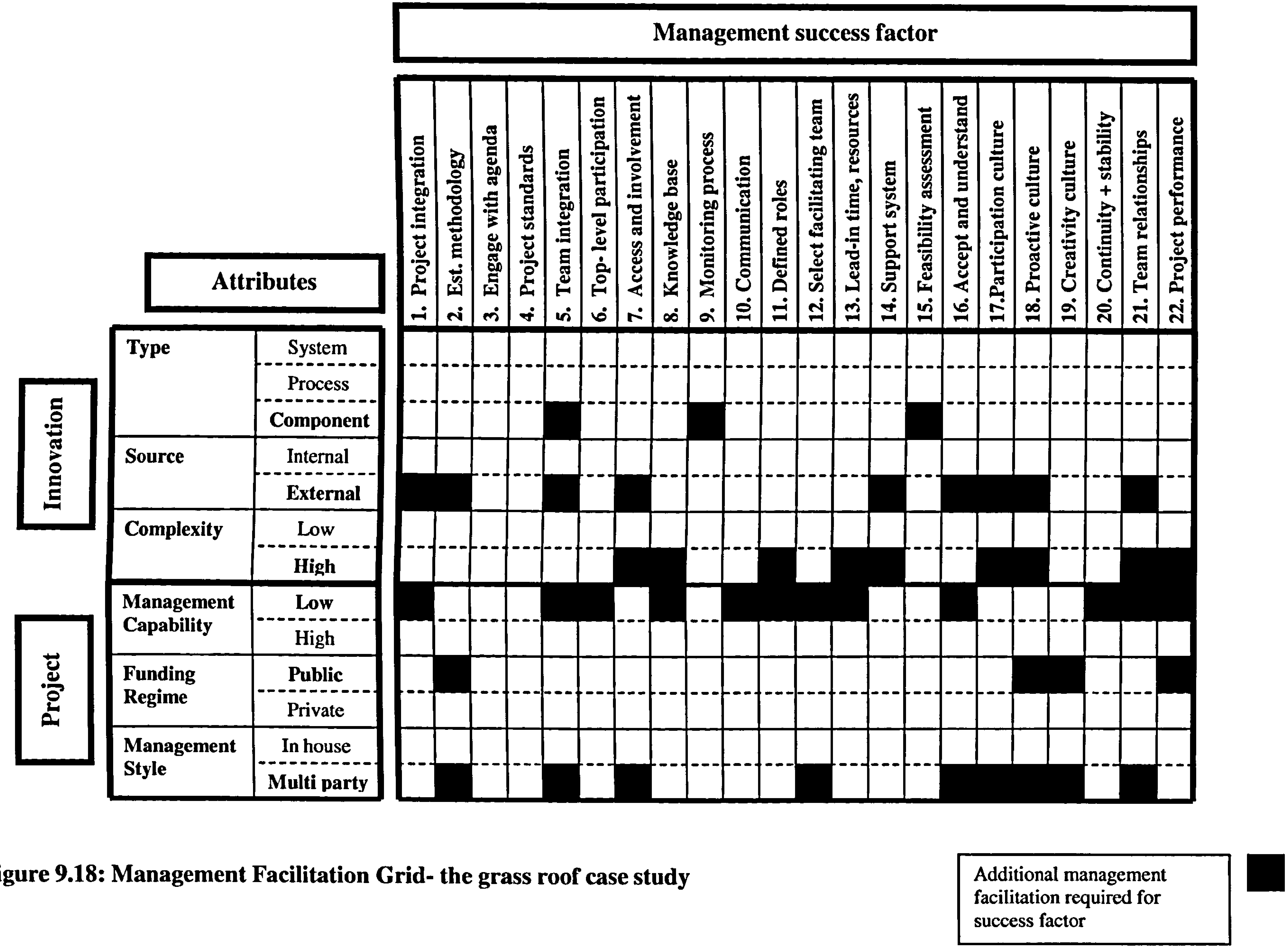


Figure 9.18: Management Facilitation Grid- the grass roof case study

the innovation process that is reflective of the context, through the identification of the form of the attribute set, and tailoring management response to provide additional facilitation where required.

9.4 Conclusion

This chapter identified, from the grounded theory, 22 generic success factors for managing the innovation process and divided these into strategic, structural and cultural factors by nature. Validation of these factors against established sets of general management success factors revealed the shared generic nature of their founding principles, with those developed within this research reflecting a tailored version of these principles representative of the needs and requirements of the construction project environment.

This chapter provided the opportunity to evaluate the influence of the attributes identified in chapter 3. This allowed for the innovation attribute of scale to be replaced by the more representative attribute of complexity, and the addition of the project attribute of management capability. Assessing the influence of the individual attributes revealed the importance for management to understand the implications of the specific form of the attribute within their context. Although all of the 22 success factors require satisfaction when managing the innovation process, this assessment revealed that due to the contrasting influence of the different forms of each of the attributes, additional levels of management facilitation are required to satisfy some of the success factors. Analysis observed that successful management of the innovation process was linked directly to a management that demonstrates an informed understanding of the specific requirements for managing the process, reflective of the form of each of the attributes as a set. The management facilitation grid aims to provide practitioners with a tool to assist in the identification and selection of an appropriate management response in line with the specific facilitation requirements of managing the innovation process reflective of the form of the attributes as a set.

Chapter 10

10 Conclusions and recommendations for future research

10.1 Introduction

This chapter aims to provide the conclusions from the research and to evaluate the potential scope for its further development. The research set out to develop an understanding of the nature and requirements for managing the innovation process within the construction project environment. The thesis presented the complex and dynamic nature of both innovation as a concept and its environment of implementation, and highlighted the practical implications of managing the process within this context. The chapter is structured in two sections with the first presenting the conclusions from the research and the second providing a review of the potential scope for developing the research further.

10.2 Conclusions of the research

Identification of the nature of the innovation and the impact of project attributes

- The research revealed that it is possible to produce a set of attributes that is reflective of the varying forms of both the nature of the innovation and the impact of the environment in which it exists. This provides a basis from which an understanding can be made of the particular context of each innovation and their environment of implementation.
- The research found that defining the form of the innovation attribute of type by the nature of its relationship with the project, was more reflective of the needs of

managing innovation within this context than traditional approaches of definition. Evidence suggested that understanding the hierarchy of governance between the innovation and the project process during their integration, provides the basis for an effective management response.

- Analysis confirmed the need to provide a distinction between innovation that is internally generated and those that are imported from external sources, and this was reflected in the attribute of source. The research illustrated that internally generated innovations require greater emphasis for management on encouraging a creative environment, whereas the focus for externally generated innovations was associated with developing a greater sense of ownership within the team for the concept.
- The attribute of complexity was identified during the research to be more reflective than that of scale. Analysis concluded that it was not the variation in the level of scale that influenced the management of the innovation, but the level of the complexity of its integration with the project. This resulted in an adjustment of the set of attributes displayed in the research and requires to be considered as a key component by management.
- The identification of management style as an attribute provides the distinction between projects that are managed in- house and those that are multi- party by nature. The observation of this distinction is necessary as evidence suggested that the in- house project environment provides greater levels of natural support to the management of the innovation process than that of the short- term temporary nature of the multi- party project.
- The nature of the funding regime of the project requires consideration when managing the innovation process. Privately funded projects were observed to

experience higher levels of natural support for aspects such as creativity and generally encouraging innovation, when compared to publicly funded projects. On the other hand the research revealed a need for privately funded projects to learn from the public sectors ability to focus on aspects such as the control of potential risk within the process. An awareness of these distinctions is necessary for tailoring an appropriate management response for the innovation process within each of these sectors.

- The inclusion of an attribute that distinguishes between the levels of management capability of those managing the innovation process was observed as necessary during the research. Evidence illustrated that a management team enjoying no previous experience of managing innovation, required facilitation to develop their understanding of the requirements of managing such a process to compensate for their low level of management capability. However, the case studies provided examples of the dangers for management teams displaying high levels of capability, of neglecting to develop their expertise and knowledge base further.

Develop a model of the innovation process

- The process of managing innovation within the construction project environment is structured around a series of three decision gates that provide the basis around which the four phases of the process are formed. Each phase displays a set of activities or factors that require management consideration to facilitate progression to the next phase through the satisfaction of the decision gate.
- Two layers of management are observed for the individual phases of the process, the phase specific management control system (providing facilitation to the

activities of the phase process), and the overall management process (providing the control and guidance to the individual phases from the perspective of the requirement of the overall innovation process). The identification of an overall management control phase highlights the need for management to consider the overall needs of the innovation process, including its integration within that of the project.

- The model highlighted the need for management to be aware of the need to be reflective throughout, and the need to ensure that feedback is achieved between the different phases and activities of the process. Failure by management to be aware of or react to changing circumstances was observed to be a problem within many of the case studies.
- Although the research observed a model that was generic in its overall structure and principles, it is the identification that it is not prescriptive in its application that provides its potential for future consideration by the industry. Analysis revealed that within each phase of the model, the appearance of the activities or factors (despite being generic in their need for consideration) were fluid and fuzzy depending on the specific requirements of the practical context in question. This awareness allows a model to emerge that is intended to be interactive by nature, with the aim of providing practitioners with the guiding generic principles from which they can tailor an appropriate management response to the needs of the situation. The identification of the fluid and fuzzy nature of the model distinguishes it from the more rigid style of modelling, and aligns it more with those that are intended to be interactive.

Assess the impact on the model of different types of innovation

- A distinction was drawn between the management of the innovation process and the management of the project process. This realisation draws attention to the need to achieve effective integration of the management of both these processes. Evidence from the case studies suggested that failure to achieve integration resulted in significant problems for the success of the innovation process.
- The research revealed that each of the three identified types of innovation (system, process, and component) displayed differing requirements for integration, due to the contrasting relationship of each with the project. There is a need for management to understand of the innovation and its relationship to the project, and the research highlighted the need for an awareness of the implications of this when attempting their integration.

Identify the management success factors for the innovation process

- The 22 success factors identified for managing the innovation process were observed to belong to three groups- strategic, structural and cultural. This allows for differentiation to be made regarding the nature of the factor to the process.
- Analysis revealed that the level of facilitation required from management in order to achieve the satisfaction of each of the success factors varied depending on the context of both the nature of the innovation and the project environment. It was apparent that each success factor experienced a natural level of facilitation that varied depending on the nature the context. This highlights the need for management to understand the nature and implications of these variations in order that they can tailor a response that is reflective of the facilitation

requirements of the context in question. The attributes were used within the research to understand these variations, and identification of the variation in the facilitation requirements for the different forms of each of the attributes was made. Analysis of the case studies revealed that an understanding of the facilitation requirements of the attributes as a set enhanced the potential for successful management of the innovation process. The management facilitation grid can be viewed as an illustration of this point, and highlights the need for those managing the process to tailor their management response to accommodate these variations.

- These variations, in addition to the fluid and fuzzy nature of the model highlight the need for a management approach that is founded on a set of generic principles but that is interactive in their application to the nature of the context. Consideration of both the innovation and project attributes as a set provides practitioners the opportunity to effectively engage with the requirements of achieving the effective integration of the innovation process within the project, and to tailor their response in a reflective manner.

10.3 Scope for further research

The nature of the study presents considerable scope for further research, through the advancement of its findings. The research aimed to produce a generic understanding of the innovation process within the project environment. The generic level of this assessment has presented an opportunity for further investigation to be conducted into its specifics and wider observations. It is necessary when conducting research such as this to view it as providing the stimulus for further investigation, as opposed to being viewed as the complete story. The findings within this research display dynamics and complexities that require the further development of understanding, in order to improve the interaction of practitioners with the requirements of the process. This section outlines some of the factors that have the potential to advance such an understanding.

Further validation of the model

- Although validation of the model was achieved, it would prove interesting to actively use content analysis as a methodology to assess the validity of the established research model. This would strengthen the validation process for the research, but is anticipated to not affect the findings.
- The next stage would be to actively implement and monitor the recommendations of the research in practice. Monitoring the experiences of practitioners interpreting and following the research findings (i.e. the model, success factors and using the management facilitation grid) within an active construction project would provide a useful empirical assessment in order to assist the further development of the model.

Increased number of case studies

- The expansion of the number of case studies would provide an opportunity to follow up on many of the specifics of the study. Research is only as good as its empirical sample. Expanding the number of case studies would enrich the existing observations whilst allowing for a better understanding.
- Increase the focus on each of the attributes. This research provided a general identification and assessment of the attributes; however, an increased number of case studies would provide a greater degree of empirical focus on the complexities and requirements on each of the attributes.

Quantification of management performance

- The increased number of case studies would provide the opportunity for the further development of the attributes. It is anticipated that the further development of the attributes would provide the opportunity for the quantification of the performance of management. This presents an exciting level of potential, as trying to develop an index figure for overall performance was not possible with only the nine case studies. Within the context of this research, the assessment of performance using subjectivity was limited; however, the potential exists to develop a quantifiable measure.
- Develop the success factors into quantifiable KPI's, in order to move away from the subjective nature of assessing performance.
- An increased sample would allow the opportunity and rank the significance of the attributes. The present research developed an indication, but not a sufficient the depth to make significant conclusions due to the limited size of the sample. This could be valuable for identifying the focus for management prioritisation.

Expansion of scope

- Use of the same methodology and objectives to assess case studies from other industrial sectors, i.e. manufacturing etc. This can provide an effective comparison of the different nature of the process and its management requirements across different industrial environments.
- Further examination of the project attributes and their broader implications is required, i.e. the difference between projects that are managed in- house or through multi- party arrangements, and publicly or privately funded. They affect not only the innovation process but also the management requirements of the wider project management.
- Some cases studies touched on environmental innovations connected to the increased drive for sustainability within construction. There is an opportunity that the observations made within this research can contribute to improving the management of such innovations. More case studies could be added to the study to allow for a full assessment of the management requirements for innovation within this context.
- Increasing the number of case studies will provide the opportunity to extend the scope of the research to assess the role of SME's in managing the innovation process within this environment, in addition to assessing the implications in the supply- chain. Construction as an industry is made up primarily of SME's and by expanding the scope of the research to enhance the understanding of managing innovation within this context, improvements can be made to practical understanding of the research findings, in addition to exploring another aspect of construction neglected within the research.

Application of the findings within the industry

- The intention behind the research was to provide an understanding of the innovation process and its requirements for management that practitioners are able to interact with, and use to improve their practices. Whilst this has been achieved to a degree, there is a need to package many of the findings in bite sized packages that can be digested during training courses and within practical situations.
- The management facilitation grid is a tool that has the potential to greatly aid practitioners in their approach to managing innovation within this environment. The grid allows practitioners to select an appropriate management response in their approach to managing innovation that is reflective of both the innovation and project attributes of the situation. Consultation with professional change managers and facilitators would provide advice on how to package the tool for commercial use as both a training aid and guide for practical use. The tool provides a degree of understanding of both the attributes and their individual management requirements that is currently not available.

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Appendix A

Semi- structured interview

Description

Referred to in chapter 5, appendix A provides a copy of the interview structure used within the research. The structure is broken into three sections, 1) background, 2) mapping and review of project and the interview process, and 3) future contact and access to others. In practice, every interview differed slightly due to the reactive nature of the questioning dependent on the individual nature of the discussion. However, it was necessary to have a semi- structure in order to guide the discussion to ensure that a consistency of information was available from the respondents across the sample, to enable for comparisons. The first section focused on establishing a profile of the individual, and their relationship with both the project and the innovation. These were standard questions asked in all 75 of the interviews. The second section aimed to try to understand the nature of the innovation process within the project, and to expose the experience in practice of its management. This section used a template of 2 phases of questions relating to 1) the project and 2) the innovation and its process. Within this discussion, the emphasis was placed on the respondent to provide the thread for the discussion and this allowing the issues to emerge. The template was used to ensure that no issues were neglected. The third section provides a reminder to the researcher concerning the need to establish the nature of future contact, and the potential for gaining access to other members of the team. This was an important component of any interview, as the research depended on the facilitation of relationships with teams members throughout the process.

Section 1- Background- the project, the individual and the organisation they are involved.

1) To establish a profile of the respondents position/ relationship with the project.

   a) understand who they are
   b) who they work for
   c) their position within the hierarchy of their own firm
   d) their position within the project i.e. hierarchy
   e) establish relationship with the project- i.e. client, contractor, sub-contractor, etc

2) To establish a profile of the organisation to which they belong- relationship to the project

   a) organisations main strategic focus- i.e. income, work orientation, employment focus, marketing etc.
   b) level of importance that this project represents to the organisation
   c) previous experiences with similar projects
   d) have you worked with any of the participants of this project previously
   e) the type of relationship which the organisation traditionally takes with external organisations- i.e. joint- ventures, partnership agreements, etc.

Section 2- The mapping of and review of the management of the project and the innovation processes

The interview requires the generation of two types of map for the two phases of discussion-

Phase

1 The project
2 The innovation and its process

The aim is for two maps to be generated representing -

a) **the levels-** the hierarchy i.e. the decision makers and the identification of the power structure

b) **the stages-** the display of stages of activity over the duration of the process from the idea formulation to the final construction

Phase 1 of the interview- *The project and its management.*

Profile of the project

i. nature of the project
ii. objectives of the project
iii. geographies of the project- i.e. location issues, suppliers and contractors, headquarters etc.
iv. at what stage did your organisation become involved with the project?
v. what was the nature of this involvement

1) Need to map the project management hierarchy
i.e. the power structure of the project in terms of the decision- makers who exert control.
2) Map the contributors on the project- i.e. the contractors and participants to the project.
3) The variety of the different personal involved on the project, at all of the different stages within the project which they contribute, i.e. designers etc
4) A map of the project over time, from idea formulation, i.e. planning to finished construction

A developmental model of the project from idea formulation to the finished construction and the major stages involved over time
Roughly what is the time scale governing the project- phase by phase

5) A map of your organizations project hierarchy (power structure)
6) A map of your organization's involvement in the project, in terms of phases over time from idea formulation/ to finish construction.
7) How did the need for the project come about?
8) Identify the decisions behind the nature of the project (who was involved, power relationships, resources, etc).
9) Describe the culture within the project concerning the generation and sharing of new ideas.
10) The flow of ideas / communication routes within the project.
11) Need to identify the barriers to the achievement of optimal performance within the project stage by stage, and level to level.
-Stemming from idea generation right the way through to problems expected at the finish of construction.
12) The relationships between the contractors and the different levels and stages of the project.

13) A summary of any aspects within the project that presented problems

For example-
- Cultural Problems
- Structural Problems
- Leadership Problems
- External Problems

Phase 2- *The innovation and its management*

1) What is the innovation within the project

   a) the nature
   b) its objectives
   c) why it was deemed necessary
   d) how novel is this innovation- either new to the industry, or new to organisation
   e) do you and/ or your organisation have any previous experience with such a change of practice
   f) the previous experience to which your collaborators within the project have with the innovation

2) Where did the innovation idea originate from

   a) internal source
   b) external source
   c) whom in the organisation either brought it to the project, or created the concept
   d) what position do they occupy within in the hierarchy

3) Academically it has been identified that over the course of an innovation, i.e. from idea creation to the finished process, that an innovation will take a common journey, traditionally passing through three periods along the journey. These three periods experience a number of key junctures.

- The aim of this section is firstly to identify if the innovation under consideration passes through these stages of development, by mapping the process of innovation over the course of its duration.

   a) **map without consideration of the journey model**

      1) Identify the main phases that the respondent sees within the lifespan of the innovation, from idea formulation until the end of the process.
      2) Within this process it should be possible to identify where the idea came from and how the innovation passed through the project hierarchy in terms of individual's involvement during decision-making.
         I.e. was this a strategic decision?

   b) **Using the innovation journey model**, attempt to map the process in relation to the junctures prescribed within the model. (use the sheet marked components of the innovation journey)

      Within this sub- section it is important to identify the cultural and structural barriers existing towards the progress of the innovation.

      Enter on marked sheet, detailing –

         who were involved (position, organisation)

what problems existed within this process?
how were the problems resolved?
and how did this stage relate to the overall project

c) **identify the major cultural barriers towards the progress of the innovation process within**

- the innovations development that has not been covered in the above questions
- the cultural barriers which exist within the project in terms of its implementation, i.e. using the power management hierarchy map of the project and innovation, identify the level of resistance at each level.
  i.e. the projects ability to implement the innovation, barriers to its success, i.e. designers, project management, contractors, site workers (professionals, and labourers)
  How important do you feel a motivated project is to this process?
  - Describe this resistance.

Make sure that issue's such as
1) the importance of good communication within a project
2) the importance of good co-operation between different levels of the project, and different stages is covered
3) how innovative do you feel the project is in general- at all levels and stages
4) how acceptant of new ideas are the different levels/ stages of the project
5) how good are the different levels and stages of the project in relation to problem- solving?
6) are the problem- solving and innovation within the project conducted in a team or a group basis?
7) how does a multiple party project become innovative, i.e. multiple chains of command etc.

Etc

d) **How successful was the innovation-**

- in this case, in reinventing the culture to which a project is managed
- how effective is the project in meeting its objectives, and did the innovation improve the ability of the project to do this
- would you use this innovation again
- would you make any changes to the innovation
- would you make any changes to your organisations interaction within the innovation
- would you alter the management of the innovation process

Section 3 Future contact over the course of the process, and contact with other team members

Points for consideration

Inquire about the possibility of

a) returning at some point in the future to ask more detailed questions
b) achieving access to the other collaborators within the project
c) achieving access to a number of people within the project at a wide range of levels within the management hierarchy.

Appendix B

Review of case study projects

Description

Referred to in chapter 5, appendix B provides a review of each of the case studies, providing a brief overview of the project, the nature of the innovation and the experience of managing the innovation process. The structure of the thesis did not provide a discussion of each individual case study but favoured to focus on the findings of the comparison across the case studies. However, it was deemed helpful to include such a review in the appendix, in order to provide the reader with a context of the case studies. Each of the reviews also includes details to the attributes identified at the point of selection, to aid the reading of the reviews. The experiences of managing the innovation process within the individual case studies is constantly referred to during the thesis, however, these references relate to specific issues being discussed. These reviews place some empirical context behind these references.

List of projects

1. Case study (1)
2. Case study (2)
3. Case study (3)
4. Wind turbines
5. Demolition waste recycling
6. Reed bed gully waste
7. Grass roof
8. Passivent
9. Roof institution material

1 Case study (1)

Attributes (at selection)

Type of innovation:	System
Scale of innovation:	Incremental
Source of innovation:	External
Project management:	Multi- party
Political environment:	Publicly funding
Specifics of innovation:	Partnering, 1 project/ 4 phases

Description of the project
The project involved the construction of a new primary and secondary school on the existing school site. The project required to maintain the education of the pupils on the site throughout the construction phase. Four phases were planned 1) groundwork, 2) primary school, 3) secondary school, 4) sports facilities, with a planned construction phase of 4 years. The estimated value at the beginning of the project was £12 million. The client was a district council who where keen to attempt to manage the project using partnering as a procurement route. As a project, it was deemed a success as it only ran slightly over budget and over time. The management of the site with relation to the need to facilitate the change over of schools and the need to ensure the safety of those using the site was deemed particularly successful. However, although the project remained on track, this was only achieved through alteration (unplanned) to the procurement route as the project team reverted to a traditional method in order to accommodate the considerable financial and problems with delay, experienced during phase 2 and 3. These pressures nearly resulted in the loss of control of the project by management, however after a trying period for everyone involved the project they regained control of its objectives.

Nature of innovation
The council desired to use partnering as a form of procurement using the same project team over the 4 phases. The council are relatively forward thinking concerning methods or innovations aimed at improving the performance of the construction industry, as they had recently completed a number of adversarial natured projects and were keen to find a solution to this. The client conducted both considerable research into the concept and development of its practical application. The client selected the project team based on an open competition of selection, particularly for the architect and the contractors. The architect was selected because of their positive and youthful outlook to the industry,

which was felt to be reflected within their design and acceptance of the innovation. They also demonstrated experience of the innovation within other projects. The contractor was selected because of their positive outlook towards the innovation also, and their desire to develop expertise of its use in practice. The quantity surveyor, the planning supervisor and the structural engineer were all selected to the team through open competition. However, it is clear that previous relationships and recommendations played a part. None of the members of the team had experience of this type of partnership previously, although the architect had worked on housing projects using alternative styles of partnering, and the contractor's organisation has used it previously but their project personal had not. Consequently, this resulted in a team that viewed the use of the innovation as a novelty. The project was funded by the council's education department and as a result involved a significant level of public scrutiny. The personal from the client body illustrated personal enthusiasm for the innovation and championed its use, although there existed a culture of doubt amongst top-level management within the council. The concept aimed to retain the same project team throughout the 4 phases of the project, thus retaining continuity and a team like atmosphere. The use of partnering also allowed the team to overlap the design and construction phases of the job. The ongoing nature of the design phase was intended to emphasis the strength of the partnership and creates a process that was responsive to the needs of the site. However, it is clear that this in practice caused many tensions within the team resulting problems for the innovation.

Experience of managing the innovation

The initial and development phases of the innovation process can be viewed as successful on the surface. The client base supplied plenty of resources for the concept with time being allocated within the project schedules for discussion sessions and workshops relating to the practical implications of the concepts use. The client led these discussions and aimed to involve the team (at all levels) as much as possible. However, despite the positive start to the process and the good team culture that was developed during this period, three important aspects over this period resulted in problems for the innovation during its implementation. 1) the partnership failed to include the sub- contractors and those at site level, resulting in a lose of influence from site level within the projects management, 2) the change of personal in the contractors team, bringing a change in mindset regarding their participation from positive to one of negativity regarding the value of the innovation, and 3) the failure to limit changes within the design phase to the point that delays and pressure was placed on the construction phase. These three problems although not regarded as significant during the early phases of the project resulted in problems in the later phases of the project for the innovation, as the resistance towards its use in practice increased. Despite the good start to the innovation process, the client body failed to support the concept during the implementation phase. The client withdrew as a presence from the management of the project, favouring delegation of responsibility over physical participation. This had a destabilising effect as although the team were technically capable of fulfilling their roles within the project, they struggled with the innovation and its use in practice. The concept lacked leadership and support during the implementation phase resulting in its ultimate failure. The pressures exerted during the project relating to the integration of the design and construction phases of the project resulted in both delays and budget considerations dominating the progress of the project. These pressures placed considerable strain on the cultural relations of the team with many participants falling out on both a personal and professional level. The change of personal on the contractor's side brought in individuals that were less committed to the innovation and were happy to steer the projects management towards a more traditional style and abandon the use of the partnering approach. The remainder of the team due to the strength of the contractors influence and the need during crisis periods to achieve the set objectives were happy to drift more to a traditional management approach. Without the influence and support of the client, this allowed the use of the innovation within the project to become unrecognisable to what was intended. The lack of a champion for the use of the innovation, the dominance of a grouping within the team who rejected its use and the desire to seek the familiar and trusted methods during crisis periods resulted in the innovation failing to exist in any form other than name towards the later period of the project. Although the project achieved many of its objectives with relation to budget and timescale, it is clear that the cultural damage to the team caused by the failure of the innovation, resulted in a lot of bad feeling that could not be repaired. This project demonstrated a team where there were stark contrasts in the approaches of some individuals towards the innovation, with some such as the client, architect, and school representative being positive regarding its use and disappointed with its failure, and the contractor, quantity surveyor and planning supervisor being negative and actively working against its use. The client required to maintain control of the situation through both active monitoring of its progress and the required intervention of support when necessary. It is clear that this could have appeared both in terms of structural and cultural support.

2 Case study (2)

Attributes (at selection)

Type of innovation:	System
Scale of innovation:	Incremental
Source of innovation:	External
Project management:	Multi- party
Political environment:	Publicly funding
Specifics of innovation:	Partnering 1 project/ 2 phases

Description of the project

The project was to construct a significant number of social housing as part of a city council's regeneration scheme. The client was a housing association, and they won the contract for the sites through open competition with other housing associations. The client representatives of the housing association were based within the city; however, the housing association was a subsidiary of a national housing association based in England. The project was split into two phases, of which they overlapped in timeframe, with the sites being separated geographically by a main road. The funding agency for the project were keen to support the use of partnering as a procurement method of the two phases of the project as they felt that a constant project team would assist the performance of the project both culturally and structurally. The project involved the construction of 50- 75 timber kit framed housing, with the kit supplied by a local manufacturer. The housing associations parent organisation supplied the architect for the project who used a familiar design to the organisation. The design represented a low risk to the project; however, complications stemmed from the condition of the site, which presented problems relating to both cost and time for the project. The first phase of the project experienced considerable problems at site level particularly as service cables were discovered to run through the site with drastic implications for both the cost and time scale of the construction phase. The problem was exaggerated due to the reduction of the funding allocation by the funding agency placing pressure on the project team and the overall management of the project. The project team was selected largely though previous relationships with the architect, quantity surveyor, planning supervisor, structural engineer and the client having worked together as a team. The contractor however, was selected in open competition and had no previous relationship with any of the team. There was a grievance within the established team over the selection of the contractors, as they were favoured over local contractors. The innovation intended to tie the team together both structurally and culturally in order to improve the integration of both phases of the project. The first phase of the project was completed experiencing some delays and additional costs, however it was clear that the second phase preformed to much improved standard due to management intervention and a clear recognition that as a project team that their required to be an improvement in the communication pathways.

Nature of innovation

The parent housing association were keen to promote the use of partnering within this project. The project received high-level management attention from the national based organisation, as they desired to make partnering the standard approach for all housing projects that they implement. However, the organisation's subsidiary in Scotland had never used partnering, and the parent organisation was keen to use this project as a pilot for the development of this procurement method within Scotland. Therefore, the parent organisation supplied their chief architect for the project due to his wealth of experience on partnering projects down south. However, the remainder of the team had no experience of the concept in practice, including the personal involved from the contractors firm. The contractor was selected largely based on its desire to use the innovation and on its apparent familiarity with the concept. However, in reality the contractor's team displayed very little knowledge of the concept and had no previous experience of it in practice. It was decided to adopt a specific type of partnering contract within the project that none of the project team had previous experience of, i.e. PPC2000. This was novel to the entire team and resulted in a high degree of uncertainty. The innovation was influenced heavily by the events on site, and therefore the partnership never really got started in all but name until the second phase.

Experience of managing the innovation

The initial and development phases of the innovation process were poorly managed, resulting in the failure of the concept to manifest itself both structurally and culturally within the first phase of the project. Although time was spent as a team during the initial period of the project with meetings and workshops there was a failure to actively transmit the benefits of this into the activities of the project. The project team were engaged with the concept of the innovation at an early stage and demonstrated on the whole an appreciation for its benefits and a low level of resistance towards its use, however there was a distinct lack of understanding of its implications in practice. This resulted in confusion and a trend to carry on in a traditional manner. Analysis revealed that this problem emanated from the client representatives (leader of the project) lack of understanding of the concept theoretically and inexperience in its practical implications. These problems were made even worse by the lack of support that he was given from top-level management from the parent organisation. They had decided on the use of the concept and then provided very little resources to the client representative in Scotland to assist in its implementation. It was clear that the particular version of the innovation (PPC2000) was selected by members out with the project team, and therefore no feelings of ownership were fostered from within the team and certainly not by the client representative. The pressures of the first phase of the project regarding the budget reduction and the complications on site resulted in a race against time to get the project onsite following the design phase. It is clear that the need for speed and a tightening of costs resulted in practice in the project team rejecting the use of the innovation in favour of a traditional method of working. The team displayed a distinct lack of understanding for the concept and its implications in practice throughout the first phase. Poor communication pathways between the team members compounded to enhance the lack of understanding of the concept, and individuals reverted to traditional practices as a means of getting on with the project. The client representative was keen also to achieve progress of the projects objectives and was happy to focus on achieving a successful partnership in phase 2 as the pressures during phase 1 made its use difficult and risky to the success of the wider project. The lack of assistance from the top- level management of the client body and the confusion caused by the failure of the architect to grasp what was going on at a practical level resulted in the innovation being under resourced and poorly lead during every stage of its implementation in phase 1. The contractor also due to their late entry to the project team felt out with the main decision making body of the team. This posed problems with relationships within the team, but also produced a lack of support for the concept from the contractor because of their feelings of lack of ownership. The contractors also experienced problems relating to their internal communication and decision-making structure with the project.

Phase 2 of the project represented a considerable change in the progress of the use of partnering. A meeting was arranged following the experience of phase 2, organised by the client representative to gain feedback in order to address the problems experienced in phase 1. Communication was highlighted as the single most significant issue requiring attention. Through an improved level of communication, increased familiarity with the project team of each others working methods and practices, and a genuine desire to give partnering a go within the team, phase 2 was able to actually implement the innovation in more than just name. The second phase of the project did not experience any unexpected problems in the manner that the first phase had at site level, and this presented the opportunity for team members to spend more time on the function and practical needs of the innovation. The technical aspects of using PPC2000 due its complex nature represented a difficulty in the time constrained first phase as team members simply could not get their heads around its practical implications within a pressure situation. The increased level of understanding and improved level of focus placed on the importance of the concept lead to a vast improvement within the second phase. However, it is clear that the poor management of the initial and developmental phases of the innovation process resulted in considerable barriers that required to be broken down in the later phases. The use of the innovation within the second phase was improved from the first phase, although it was by no means perfect, especially from a financial point of view where budgets and costing remained tied to traditional methods due to the complexity of PPC2000. The inclusion of the site level (i.e. sub contractors) within the partnership failed to materialise in either of the phases. Therefore the benefits of the innovation to the performance of the supply chain were not felt.

3 Case study (3)

Attributes (at selection)

Type of innovation:	System
Scale of innovation:	Radical
Source of innovation:	External
Project management:	Multi- party
Political environment:	Publicly funding
Specifics of innovation:	Partnering strategic, 5 projects

Description of the project

The project involved the construction of social housing (mixture of flats and housing) over five different sites spread in various locations within a small city. The five sites represent five different construction projects that were won as contacts by a Housing Association. The contracts were won individually, however they came up at the same time and were purchased from the council. The funding agency was supportive of a strategic approach adopted by the housing association and awarded the funding for the contracts based on their decision to adopt partnering as their route for procurement. The competition was open with other housing associations, however the package offered by the housing association and their partnership with an established contracting firm and a design team all based within the city won the funding and the contacts. The project was managed by the client representative, and employed a 3-tier hierarchy for managing the team involving different members of the team at the relevant stages. It is anticipated that the housing partnership would be used to attract more contracts and maintain the team. Apart from the client and the contractor, the rest of the team had all experience of working with each other at some point.

Nature of innovation

The innovation represented a strategic use of partnering as a procurement route. The concept of using one team to govern five different projects was encouraged by both the client and the funding body as a mechanism for achieving continuity both structurally and culturally through the five projects. The partnership came together through personal relationships as opposed to a selection process with long established relationships existing between all members except the client and the contractor. The contractor was selected in competition but was largely achieved due to their close relationship with the quantity surveyor and planning supervisor. The structure of the partnership was divided into a number of levels, 1) the core group (including client representative, member of the funding agency, top management from the housing association, top level management from contractors organisation, and clients agent), 2) the design team (architect, personal relevant from contractors, quantity surveyor, client representative, site agent, site managers etc), 3) the products group (those connected to the consideration of innovations within the design), 4) site team. The structure intended decision making to be conducted at the relevant level and ensured that the relevant members of the team's involvement were tied within the process. The structure aimed to ensure that the organisations participating were involved in the project at every level thus enhancing communication pathways relating to the project internally as well as those between different members of the team. The contractor was identified as conducting architectural services for three of the projects internally and two of the projects involving an architectural practice. It was anticipated that the structure would allow flexibility between the projects whilst retaining the overall partnership. Partnering was new to all of the project team members involved, apart from the client base who had been involved in a limited version previously. However, the scale and choice of structure used within this example was novel to everyone in the team and thus can be regarded as an innovation.

Experience of managing the innovation

The structure laid out for decision making within the project team was established with full consultation of the entire team. This level of involvement and cooperation was a feature of the project team generally, but was a particular reason behind the success of the innovation process. The initial and developmental phase of the innovation process was relatively successful in their objectives. The use of the innovation was accepted unanimously by all team members and greeted with a degree of intrigue and desire for its use. Although the idea originated from the client base with influence from the funding body, it is clear that the entire team generally took ownership of the idea due to their involvement at the beginning of the process. The contractors allowed a visit through its parent company for the core group members to visit a project currently using the innovation in order to allow them to ask questions and learn about the practical implications of its use. The innovation formed the basis of the management for the projects and its importance was recognised by the team because of the need for their success. Sufficient time and structure was allowed within meetings to ensure that the concept was resourced to an adequate level particularly during the early phases.

Each of the projects demonstrated a mix of performance relating to the achievement of budgets and timescale. This depended predominantly on site conditions. However, it was noted that some of the earlier projects experienced problems relating to the quality achieved on site, of which responsibility for the poor levels were assigned to the contractors and their sub contractors. The clerk of works actively challenged the contractors over this issue and together with the client body made it clear that this was unacceptable. Whether the persistence and personality of the clerk of works drove the standard of quality higher or whether the structure provided by the partnering for raising such issues at all levels of the team, is unclear. However, it can be noted that the opportunity for constructive criticism and the ability to force action and change when required was certainly achieved using the innovation. The project team felt happy with the use of the innovation throughout the project, and whilst there were improvements that could have been made, overall the innovation was viewed as a success. Structurally the client retained control and leadership over the process throughout, and the use of a debriefing session at the end of every project provided an excellent form of maintaining feedback for improving the process.

There were certain problems that were noted however, and they related to the lack of an integrated supply chain within the partnering down to the site level. The contractors maintained a traditional format to their running of the site, with sub- contractors not invited into the partnering structure. As a result, they answered solely to the contractors and were not reused throughout the projects. This created a barrier between the construction team and the consultants that created some tension. The architect's used in only two of the projects felt side lined somewhat from the remainder of the team and many of the decision-making activities within the partnering. This was not ideal culturally; however, it was countered by the ability of the contractors to integrate different levels and departments of their organisation within the partnering structure due to their role as design and builder on three of the projects. The client however has decided to end the partnership following the completion of the fifth project due to the poor quality on site. Although this issue was resolved in the short term the client, feel that they would prefer to work with a different contractor in an attempt to integrate the full supply chain in order to improve the quality on site.

4 Wind turbines

Attributes (at selection)

Type of innovation:	Process
Scale of innovation:	Radical
Source of innovation:	External
Project management:	In- house
Political environment:	Privately funding
Specifics of innovation:	Wind turbines

Description of the project

The project involved the construction of three wind turbines for the generation of electricity for a large manufacturing plant. The factory employee's nearly 1000 people and is located on the edge of a large urban area. The turbines are intended to cut the factories reliance on the national grid for its electricity supply and thus save a considerable amount of money through its production onsite and from a renewable source. The organisation was keen in attempting to improve its environmental credentials and felt that this was an effective manner of hitting targets set by the environmental agency regarding CO2 emissions for industrial instillations. An in-house team, headed by the factories chief engineer, managed the project. Indeed, it was clear that the chief engineer would conduct much of the planning and technical side of the job personally, and this reflected the magnitude of the importance of the project for the factories future. The factory manager was supportive of the concept and following favourable responses from government bodies and top- level management of the organisation (multinational) was keen to ensure its success. The concept itself was inspired from the drive currently within Scotland for the construction and development of wind turbines and farms. In addition, the chief engineer had witnesses the use of wind turbines at an industrial insulation in Liverpool and felt that it could be applied to this context. The organisation viewed the use of the wind turbines within this context as a pilot for its consideration within other factories. The project represented the first use of wind turbines of this scale in an industrial setting so close to an urban area. As with all wind turbine projects in Scotland at present there was a considerable problem relating to gaining planning permission from the city council due to considerable opposition from local residents. This problem represents that construction projects require to consider at length the validity of its existence concerning the interests of the wider stakeholders and not just the organisations needs.

Nature of innovation

The project within this case study clearly represents the innovation and is described above. It is necessary to note however that the innovation is novel within Scotland and to the organisation itself within this context. This novelty and willingness to try something relatively risky stems from both the opportunity and a potential need due to the rising costs of energy production. The idea was generated very much from internal sources within the organisation and principally by the chief engineer. Top-level management within both the organisation and those in the factory supported the concept. There was a need for the project to be considered in a professional and united manner in its presentation and execution due to the public scrutiny that it received.

Experience of managing the innovation

The management of the innovation process within this project ran smoothly, certainly compared to the other case studies. The factor that stands out the most with this regard relates to the presence of an established organisational approach to project management, which all employees are familiar and experienced with. This approach represents a series of stages and activities that require to be passed through in any project that the organisation participates in. The understanding that the team demonstrate with this methodology makes the process of accepting and managing innovation a lot more straightforward than many other examples. The project is managed and controlled in house within the organisation, this leads to an established culture and structure being established governing the approach of the team to the innovation. The nature of the industrial sector also influences the ability of the management team to implement a successful innovation project. The manufacturing firm actively peruses innovation in every aspect of its activities. As a result it is clear that innovation is seen not so much as a risk within the team but as an opportunity that requires to be given a chance to prove itself as viable. The innovation process clearly identified the concept as viable in the early stages when it was applied to a strict criterion of financial and practical assessments. The culture of the team was such that no resistance towards an idea was assigned without the failure of any of these assessments. This is something that was not evident in any of the multi- party projects. The common structure and culture also ensured that individuals from any position or geographical position within the organisation could understand the process within this project and interact with it immediately. The project team comprised of members from all levels of the top management of the organisation, and involved participation of individuals who has little time and resources to allocate to the project. As a result, the focus for the project feel on one individual i.e. the chief engineer, however this worked well as he had access to resources and was in a position to make decisions himself due to his high position within the organisation. He demonstrated considerable ownership for the concept and his enthusiasm for it to work drove the concept in to a practical reality. The team employed an external consultant to assess the implications of using such an innovation, and this was useful for providing the team with the knowledge base required. Contractors were to be appointed at a later date; however, it was felt that this would not represent significant problems to the project team as the basic construction activities were deemed straightforward despite the scale of the project. The principle problems of the project were to assess its viability and its method of integration with the industrial process of the factory, however the strict methodology for assessing the innovation laid out, meant that these assessments were understandable and straightforward. The main problem that the project encountered was primarily with the council and achieving planning permission. However, this was an activity that was resolved through a sustained media and community based engagement program aimed at winning the community over. The project has to this point not been completed due to ongoing wind assessment trials, however once this ahs been assessed no problems are anticipated with the construction as planning permission has been granted and the contractors will be experienced in this type of work.

5 Demolition waste recycling

Attributes (at selection)

Type of innovation:	Process
Scale of innovation:	Radical
Source of innovation:	Internal
Project management:	Multi- party
Political environment:	Public funding
Specifics of innovation:	Demolition waste recycling

Description of the project

A city council through funding from the Scottish Executive required, through a series of projects, to redevelop the road transport links from the city centre to its northern boundary. The scheme involved a number of projects aimed at improving many of the existing junctions, widening roads and creating new roadways. The project team involved the chief engineer for the council and his city engineers department. They provided the consultancy for the projects; however, they were encouraged to create a partnership with a principle contractor and a sub contractor who provided specific skills relating to plant. The project in question relating to the innovation involved the construction of a road link over an area filled with demolition material. The structure of the land was unsuitable for building on as although it was stabilised it was simply covered over with grass. The demolition material was taken from a series of tenements that had been demolished in the 1980's. The tenements had large deep basements and when filled initially the buildings were not stabilised to a degree that the land could be reused for construction. As a result, the project required to stabilise this land to enable the road link to be constructed. The traditional method would have been to remove the demolition waste and take it away from the site, demolishing the basements properly and filling with a suitable material. The council who are keen on recycling, along with the contractors who share a similar interest and expertise decided that a more sustainable solution was to recycle the waste.

Nature of innovation

The innovation represents project within this example, and involved the reuse of the excavated demolition waste and its reuse as fill on the established slop. This was a novel task for the project members and on this scale must be recognised as novel of the industry, certainly in Scotland. The desire by the city council to include this activity within the carbon quota for the year produced by the council was deemed extremely advantageous for taking pressure off other aspects of the council's activities through the sheer quantity that this innovation represented. The innovation had the very real potential to save money for the council in a number of aspects from transport costs, disposal of demolition waste through land filling, buying of fill material etc. The project team had no real previous experience of such an innovation, although conceptually they accepted the idea immediately due to its recognised need and the only acceptable solution. Despite this acceptance, there existed a degree of uncertainty and risk over its use; however, this is a problem that would have existed within this project regardless of the solution, as the problem was the same regardless. The innovation was recognised as the only real solution to the specific problem.

Experience of managing the innovation

Due to the project representing the innovation, its stages and phases of development were the same. The project represented a series of challenges for those participating, and issues connected to budget and timescale added significant pressure to its progress. The management of the innovation process structurally followed the pattern of a traditional project, and this format suited this innovation well as to many within the team the innovation represented a classic piece of problem solving. What makes the innovation a good example is that although it is rooted creatively as problem solving, the dissemination activities and the long-term view of the client turn it into an innovation through their desire to apply it to other contexts. The innovation during its process received constant feedback and monitoring as this was a feature of the project, and this ensured that adjustments could be made to the process. Technically, it can be argued the innovation was a success, as the project was designed and constructed effectively. However, the teams cultural ability to cope with pressure and the uncertainty attached to the execution of the project in practice resulted in tension and a negative relationship developing amongst the team. The project ran over on cost and time due to an insufficient budget being put in place at the beginning and added complications being discovered during construction. These were problems that should perhaps have been evaluated in the early phases of the innovation process, and although it is clear that it may have been difficult to avoid these problems, contingencies should have been made for their likelihood. The management of the innovation failed to allow for eventualities that were out with their control prior to construction. The cultural tensions within the team resulting from the failure to account for such eventualities resulted in relation ships within the team being damaged beyond repair. This had serious implications for the remainder of the projects within the partnership. Indeed this example illustrates how the use of another innovation within the project can have negative consequences on another, i.e. the use of partnering within this context. The management of the partnering as an innovation process within this project had many failings constant with case studies (1) and (2). The impact of the problems of the use of patterning i.e. cultural and structural resulted in an inability of the project team to cope with the pressures of the rising cost and failure to maintain timescale. This factor requires to be addressed within the management of an innovation process, as although there is a need to ensure that the innovation does not influence negatively on the overall project, there is a need to ensure that the project does not affect negatively on the innovation process. Both of these issues were relevant within this context.

6 Reed bed gully waste

Attributes (at selection)

Type of innovation:	Process
Scale of innovation:	Radical
Source of innovation:	Internal
Project management:	In- house
Political environment:	Privately funding
Specifics of innovation:	Reed bed gully waste treatment plant

Description of the project

Like the previous two case studies, this project represented the innovation, and therefore the innovation process remains the same as that for the project. An organisation noted that there was an opportunity to change the manner to which they treated and disposed of roadside gully waste material. The council has a requirement to clean and remove this material from roadside gullies. The council in this particular city contract out this task to an organisation that has considerable expertise in recycling waste material. The gully waste traditionally is land filled, however the organisation noted that a change in the environmental regulations (landfill tax) would significantly increase the cost of this activity. The contracts manager of this operation presented the idea that it was possible to dispose of this material by removing the pollutants first through a process of reed beds. The reed beds absorbed the pollutants and through a chemical reaction remove the threat of the pollutant. The waste material that is then remaining can be land filled without being regarded as a pollutant thus avoiding the landfill tax. The project was the construction of a facility for this activity including aspects such as a loading bay for the tankers, reed beds, tanks for the water and a duck pond for the processes fluids. The organisation already owned a site that was suitable for this task. The contracts manager provided the idea and enthusiasm for the concept and presented it to the board of the organisation for support. An external consultant familiar with reed beds was brought in to the team to provide the necessary technical and scientific expertise, as well as to supply and plant the reed beds. Due to the unknown nature of the process, close consultation with SEPA regarding both monitoring of the regulations and the use of their knowledge base was achieved. A construction team was employed to carry out the practical building activities however; the difficulties of this project lay in ensuring that the design works as the practical building is very straightforward. The idea was controlled in house within the organisation and therefore fell under the structural and cultural processes and dynamics of the organisation. The organisation viewed the innovation as an opportunity to pioneer a technology that if successful had the potential to save money through the avoidance of transport costs and the landfill tax. The potential also existed for the organisation to increase its market share in gully waste, or expand the operation due to the obvious need for this innovation that emerges from the regulation change. As a result, there is an incentive for its use.

Nature of innovation

The use of reed beds for this purpose is novel in a commercial operation such as this, and therefore this example represents an invention as well as an innovation. The creativity behind the innovation emanated through a complex process of problem solving, inspiration and a realisation that there was a gap in the market that could potentially be exploited through such an innovation. The innovation itself was managed using the in house approach to project management that is established both structurally and culturally.

Experience of managing the innovation

The initial phase of the innovation emerged from the work of one individual, and this was significant as he acted as the champion for the concept throughout the entire process. His enthusiasm for the concept and the potential it offered was clearly infectious for the remainder of the team. The management of the innovation followed a set methodology for project management within the organisation. This provided awareness for those involved of the phases and stages involved. As a result, team members greeted the concept with an open mind as it was clear that it would be considered by management and those involved in a thorough manner. This breads confidence in an idea and a willingness of the team to take a risk conceptually; as they are assured that if the concept proves to be, impractical it will be withdrawn. The project considered within this case study involved a follow on from an initial pilot for the concept in practice. The results of the pilot proved encouraging however still required considerable work to develop the concept to an extent that it could be approved for use. Top-level management required justification and verification prior to granting permission for its construction. To overcome this issue the contracts manager drew on the support and expertise of external individuals to assist. The inclusion of the regulator and a specialist provided an effective knowledge base to tailor the practical realities of the innovation with both the capabilities of the technology and within the confines of the regulations. Top-level management were supportive of this process throughout, and were confident to give the go ahead for the innovation to implement in practice.

Following construction the innovation project has performed remarkably well from a technical point of view and has allowed the organisation to for fill its objectives for its purpose. The design of the plant was complex, however it has proved to be easy to construct and maintain. The organisation has benefited both financially, as well as reinforcing its reputation within the industry as an innovator both locally and nationally. The organisation recognises the benefits of disseminating innovation. This is an aspect of the innovation process that the organisation places considerable emphasis. Its activities within this context were rewarded through a number of awards received for it from external organisations. The value of a supporting environment is demonstrated within this case study as the organisation actively ensures that both structural and cultural aspects of the innovation process are facilitated.

7 Grass roof

Attributes (at selection)

Type of innovation:	Component
Scale of innovation:	Radical
Source of innovation:	External
Project management:	Multi- party
Political environment:	Publicly funding
Specifics of innovation:	Grass roof

Description of the project

The construction project involved the development of a block of flats within an area of mixed (old and new build) building type. The client was a housing association and the block was intended to provide social housing for the tenants. The project was deemed a last for nearly 2 years, and was funded by a bank and a government-funding agency. The project was a multi party project, with the client playing a heavy influence in the management of the project as its leader. The organisations within the team have worked together previously on another project which was deemed to be a great success. The personal involved in this project differs from the previous example however, and involved many younger professionals. This was a great benefit for the project in the level of innovation that took place within the projects design. The design of the block set out to reflect the sustainability agenda of the client and that is encouraged by the funding agency. The previous project that the team were involved in was a radically sustainable project in both its design and its construction and was showcased throughout the industry as such. This project was a smaller project, but none the less aimed to reflect the need to increase the level of sustainability within both design and construction. The designer was a young architect who actively perused a sustainable design, and desired to produce a building that reflected this. The contractors on the other hand were not so adventurous, but were open minded enough to accept proposals that were valid and justified. The quantity surveyor laid out a criterion that was dominated by its justification by cost, and as a result never opposed any innovation on principle. The team therefore was actively perusing an agenda for innovation and this was recognised throughout the project, but limitations came based on cost and the disruption of integrating such innovations within the project environment. The project was for 22 flats and 1 workspace and was to be constructed on a narrow site, with an access problem, as a private road runs down the side of the building and access is required to the two businesses (repair garages) at the end of the road. This issue caused all sorts of problems for the project team, as the neighbours were not keen to cooperate with issues of site access during the construction phase. This resulted in practice in delays and additional costs being assigned to the project. Compensation also became an issue for the site as damage was caused to the neighbour's property and they claimed that business had been lost due to the disruption.

Nature of innovation

The innovation was to use a grass roof as a component of the project. The client had become aware of the potential of this innovation through discussions with the architect and the manufacturer of the product itself. The funding agency was in favour of its inclusion within the project and agreed to assist in some additional funding in order that it could be tried within the project. The innovation was included within the initial designs for the project and became an integral part of the design. The roof was made of a particular type of vegetation that was tough, resilient, worked as a great insulator, and was water resistance and moss like in its nature. The plant was developed by a manufacturer who supplied the product to the project. They employed a specialist contractor to lay and install the grass on the roof. As a result, the construction team were very laid back about the practical implications of its insulation, as conceptually it appeared far easier than traditional roof tilling as it was simply rolled out. The client appeared to be relaxed regarding its use due to its advantages regarding maintenance in terms of both cost and practical requirements. The only real concern related to its cost, reliability as a material, and its integration with the remainder of the project. However, it is clear that these concerns were over come through the management of the innovation process, as the flats were completed in February 2004. The innovation represented an innovation to everyone in the project team, except the sub contractors installing it who were experts (however, their contribution to the project lasted 3 days). The enthusiasm to use the grass roof emerged throughout the team, and it was felt that as long as it met its expectations and was viable then it was seen as being acceptable to the project team.

Experience of managing the innovation

Despite the multi party nature of the project team, the cultural and structural characteristics of project operated in a controlled and business like manner. The relationships between team members due to the familiarity that the participating organisations had built up remained professional and pleasant to work in. This atmosphere allowed complex concepts to be floated within meetings as they were received with a positive and engaging response. The intended culture of the project was established from the beginning, and the team recognised and understood the sustainable nature of the project and the requirement to consider innovation in its components from the beginning. Many participants viewed the participation within such a project as an experience that can be viewed as a pilot for future projects. The client representative, who displayed enthusiasm and championed the concept to the remainder of the team, floated the idea initially within the early design meetings. The architect was already on board with relation to the concept at this meeting so was able to present the practical realties of its inclusion within the buildings design. The fact that the rest of the team could visualise the innovation's involvement with remainder of the project meant that resistance was less likely. The team were prepared to let the innovation process develop the concept further, and would only be resistant to it if there was a failure to guarantee its viability to the overall project. The concept was effectively resourced in terms of time and considerable emphasis was placed on educating the team members of its implications in practice. The contractors in particular were favourable to the innovation throughout the process as they viewed it as easy to install and were convinced that it made their job easier in the end. It appears that the team judged the concept based on whether it was fit for purpose, asking was it cost effective and what were the implications on their personal role. With a component, innovation such as this it appeared that acceptance and engagement of the team for the idea could be achieved through the satisfaction of these criteria. The innovation itself was seen as a significant component of the project and as a result, its linkages with the remainder of the project resulted in alterations to the other components in order to accommodate the innovation. This meant that it accepted and protected during difficult periods for the innovation process. The management of the innovation process was not perfect by any means, and could be argued to be successful largely through the cultural reception it received from the team as opposed to its management. However, it is an example of a multi party project that was able to innovate without the problems experienced within other case studies. It is possible to argue that this was related to the cut and dry nature of assessing its potential or viability.

8 Passivent

Attributes (at selection)

Type of innovation:	Component
Scale of innovation:	Incremental
Source of innovation:	External
Project management:	Multi- party
Political environment:	Privately funding
Specifics of innovation:	Ventilation system

Description of the project

The construction project involved the development of a block of flats within an area of mixed (old and new build) building type. The client was a housing association and the block was intended to provide social housing for the tenants. The project was deemed a last for nearly 2 years, and was funded by a bank and a government-funding agency. The project was a multi party project, with the client playing a heavy influence in the management of the project as its leader. The organisations within the team have worked together previously on another project which was deemed to be a great success. The personal involved in this project differs from the previous example however, and involved many younger professionals. This was a great benefit for the project in the level of innovation that took place within the projects design. The design of the block set out to reflect the sustainability agenda of the client and that is encouraged by the funding agency. The previous project that the team were involved in was a radically sustainable project in both its design and its construction and was showcased throughout the industry as such. This project was a smaller project, but none the less aimed to reflect the need to increase the level of sustainability within both design and construction. The designer was a young architect who actively perused a sustainable design, and desired to produce a building that reflected this. The contractors on the other hand were not so adventurous, but were open minded enough to accept proposals that were valid and justified. The quantity surveyor laid out a criterion that was dominated by its justification by cost, and as a result never opposed any innovation on principle. The team therefore was actively perusing an agenda for innovation and this was recognised throughout the project, but limitations came based on cost and the disruption of integrating such innovations within the project environment. The project was for 22 flats and 1 workspace and was to be constructed on a narrow site, with an access problem, as a private road runs down the side of the building and access is required to the two businesses (repair garages) at the end of the road. This issue caused all sorts of problems for the project team, as the neighbours were not keen to cooperate with issues of site access during the construction phase. This resulted in practice in delays and additional costs being assigned to the project. Compensation also became an issue for the site as damage was caused to the neighbour's property and they claimed that business had been lost due to the disruption.

Nature of innovation

The innovation represented a different component of the project to the grass roof although they were implemented within the same project environment. The innovation represented an innovation of the ventilation system for the building with the aim of replacing electrical fans with a system that operated on a series of flaps and vents. The system requires no artificial power and therefore fits the sustainability criteria laid out in the design brief. The project team within the previous project used the concept; however, the intention was to use an updated version of it with the aim of expanding its use within other projects. The client handed the architect a list of desirable components for implementation within the design. The architect through a process of negotiation with the rest of the team attempted to accommodate as many as was deemed possible within both the budget, timescale and the general design. The passivent system was initially selected and included in the early designs for the project. The innovation was withdrawn from the project late in the design phase, largely because of problems relating to its integration with the grass roof. The passivent system placed too many unknowns on the use of the grass roof though the need to have the vents protruding through the roof itself. The team's uncertainty with the other innovation resulted in the passivent system being rejected, as the project team aimed to protect the grass roof due to its greater importance to the success of the project.

Experience of managing the innovation

The multi- party nature of the project operated structurally and culturally in a controlled and rational manner. This could be argued to be unusual when considering projects of this nature; however, it would have to be argued that this was achieved primarily due to the developed level of personal experience within the team. The previous review of case study (7) discusses in length the benefits of such a culture on the innovation process, and it is important to observe that this environment also applies within this case. This case study although it failed to be implemented in practice, demonstrated the value of a strongly structured innovation process with decisions guided by evidence as opposed to emotions. The management of the innovation process for the passivent system mirrored that of the grass roof in terms of its phases and the activities within those phases. All innovations on the list provided by the client to the architect were considered initially in the same manner. Some were rejected straight away during initial assessments, however some such as this case study and the grass roof proceeded to later phases. Whereas the grass roof innovation proceeded through to its physical implementation within the project, the passivent system was rejected late in the design phase of the project, and at the end of the development phase of the innovation process. Its failure to progress to the construction phase and the final design for the project occurred largely due its failure to integrate effectively with the other components of the project. The integration needs were assessed throughout the innovation process, but particularly during the development phase when final details of the design were considered. The significance of unbiased assessment based on facts was highlighted within this case. The architect was keen to persist in the use of the innovation; however, it took the rest of the team to convince her that its inclusion in the design was not appropriate. The potential risk caused by using the passivent system on the grass roof was deemed unacceptable underassessment within the process. The ventilation outlines would be required to protrude the grass roof, and the number of unknowns existing about both innovations meant that one was to be sacrificed, i.e. the passivent because it was less significant to the project. However, this experience did not deter any members of the value of the innovation, but it was concluded that it was not suitable for this particular project.

9 Roof insulation material

Attributes (at selection)

Type of innovation:	Component
Scale of innovation:	Incremental
Source of innovation:	External
Project management:	In- house
Political environment:	Privately funding
Specifics of innovation:	Insulation material for roof

Description of the project

The project was a housing development by one organisation over several phases staggered over a number of years. The organisation is a contracting company of medium size and is a major player a specific region. An opportunity came up with the sale of a substantial piece of land. The land was 4 miles outside an urban area and 10 miles from a major tourist town and golf centre. The organisation decided to build housing for the upper end of the market in the land around the golf course. This was to be a luxury housing development, with houses demanding premium prices. Wealthy business people and millionaires looking for a holiday home for the golf were targeted, along with local professionals as potential customers. The organisation decided to perform the projects in house, using a team who had worked together for years. An architect fro the housing development was headhunted from a local architect practice to work for the organisation, however the remainder of the team have been employed by the organisation for between 5- 35 years. The team were familiar with each other, and both the cultural and structural environment to which it does business. Sub contractors were brought in for tasks such as the joinery and the electrics, and the provision of some of the labour was from outside sources. However, overall the organisation supplied the personal for the project every level. The project ran over a number of different phases, and it was hoped during the final few to begin to introduce some innovations (component by type). The houses were designed individually in order to give them a unique feel. The client is involved with the architect at the beginning of construction, and much discussion takes place prior to completion. The influence of the end- user (client) on the design and build of their house is significant. The project development overall has been a success for the organisation, and the value retaining strategic, structural and cultural control of the project throughout has been realised. Such an environment generates a specific and familiar methodology for project management within the organisational from which every team follows. The structure of this process is used for the management of innovations also.

Nature of innovation

The innovation was the introduction of an innovative roof insulation material within the housing development on one of the later phases of the project. The reason for considering the innovation stemmed from a change in the environmental regulations regarding the requirements for insulation materials in a bit to reduce heat loss in new build domestic housing. The regulations will not come into affect for a few years, but the organisation is keen to try out different products on the market that meet the new regulations in order to gain an advantage over its competitors. The buyer fro the organisation contacted a number of suppliers and took samples of three different products. These were tested by the organisation to assess their suitability and then one was selected for use. The high value of the housing development allowed a sufficient margin for the use of a previously untried material, and presently expensive material. In lower value projects, this would not have been possible. The architect was the driver or champion behind its use, and he was placed in responsibility of managing its development process. The material itself was assessed early as being suitable and to have met the requirements that it was set through its objectives. Close consultation was achieved with the site team and those on site warmly greeted the process of implementing the innovation into the buildings at a practical level. The material was a lot thinner than traditional materials, lighter, and easier to implement. Although initially it is expensive, this cost will drop over time as the product gains greater market share.

Experience of managing the innovation

The experience of managing this process appears to have been a success on many different levels. The in house nature of the project greatly assisted the team in their understanding of the innovation and provided the correct structural and cultural environment to enable an easy process of implementation. Control of the innovation process was assigned to the architect and everyone within the team recognised that the innovation was being considered for the benefit of the project and therefore the benefit of the organisation. Professionally individuals did not feel they were taking a risk through the implementation of the product because they all worked for the same organisation. This resulted in the risk being spread throughout the team as opposed to examples of multi party projects were the risk is passed through the supply chain. The establishment of a methodology for the management of such an innovation process provides a level of understanding and trust throughout the team provides the security and necessary spread of evaluation to enable a successful process. The use of the innovation within the project was never really in doubt once the commitment to absorb the risk had come from top-level management. The usability of the material in practice and the obvious advantages of its use in terms of storage, eventual cost advantages etc, meant that objections to its use would have been unjustified. However, it is important to observe that the management of the process was structured in such a manner that assessment was constant concerning its suitability, and it was apparent that it would have been withdrawn had performance not matched what was promised. The use of a component innovation appears to be a lot more cut and dry than other types of innovation, perhaps due to the fact that prior to implementation into the project there is a need from a design perspective to conduct a complete evaluation of its implications. The organisational nature of the project meant that little effort was required from a cultural point of view relating to the innovation process. The innovation also presented very little practical problems with integration to the rest of the building and affected little on the rest of the components of the project.

Appendix C

A comparison of each phase of the process for the different types of innovation.

Description

Referred to in chapter 7, appendix C provides 6 tables comparing the significant activities or factors for each of the elements of the innovation process for the different types of innovations. The activities and factors displayed on the tables relate directly to the three innovation process models for the three individual types. The tables represent comparisons for 1) the overall innovation management phase, 2) the initial phase, 3) the formulation and development phase, 4) the implementation phase, 5) the handover phase and 6) selection process. The activities or factors are displayed on a grid, with horizontally the elements of the process, i.e. the phase process, factors of influence (external/ internal and cultural/ team) and the management control system. Within the overall innovation management phase, the phase process is replaced by the MPCS (management project control system) and the management control system by the MICS (management innovation control system). The selection process, in addition displays a different set of elements consistent with those identified in chapter 7. Vertically the grid groups the activities or factors for comparison, either by 1) those unique to the type (system, process or component), 2) those shared by two of the types, but not the other (system + process, system + component, process + component), and 3) those shared as significant by all (overall). These grids allow the reader to assess for comparisons easily and to identify patterns emerging. It is necessary to recognise that the activities identified only represent activities or factors that are significant for each type, and does not exclude those not identified, but suggests that they are of a lower importance.

	MPCS	External/ Internal	Cultural/ team	MICS
Overall	•Ensure integration of project + innovation objectives	**External factors** •Industry innovation culture •Governmental agenda **Internal factors** •Nature of project •Project pressures + risk	•Trust + ownership + resistance to concept •Open, listening, questioning •Involvement + participation •Strength + stability- relations •Established innovation culture •Team ability + mindset	
System + Process	•Senior management involvement	**External factors** •Client objectives/ integration		•Effective leadership + control •Integrate project/ innovation processes/ objectives
System + Com	•Acceptance of innovation			•Acceptance + understanding
Process + Component	•Established methodology for the innovation process	**Internal factors** •Context + significance of idea	•Leadership/ control/ access •Team/ group culture- shared	•Assist involvement + ownership throughout team
System only	•Engage team in process		•Communication/ information	•Top- level participation •Flexibility •Time considerations •Aid communication pathways
Process only				•Draw on experience + mistakes •Team balance + continuity •Roles + responsibility defined •Creative + pro active culture
Component only	•Elect proactive innovation culture	**Internal factors** •Problem solving capability		•Regulations- awareness •Assess options/ implications •Suitability/ fitness for purpose •Facilitate innovations needs •Satisfy project standards

MPCS- Management project control system

MICS- Management innovation control system

Overall innovation management phase

	Phase process	External/ internal	Cultural/ team	Management control system
Overall	•Idea generation •Assess viability + suitability •Initial implications + suitability •Idea presentation to team (formal/ informal)	**External factors** •Drivers + triggers •Industry innovation agenda **Internal factors** •Perception of risk + novelty	•Perception of trust/ risk •Teams ownership/ involvement •Recognition + suitability •Positive, proactive, open culture	
System + Process			•Knowledge + understanding	
System + Com			•Nature of relationships	•Long term planning approach •Early introduction •Leaders support + enthusiasm •Access/ participation to d-m •Facilitate idea creation •Draw on extra experience
Process + Component			•Supportive + positive client •Communication + idea flow	•Ensure questioning + learning + improvement culture •Research alternatives
System only		•**External factors** •Context of idea generation		•Maximise knowledge holders •Facilitate relationships
Process only	•Secure feasibility study •Plan process methodology •Assess problem + opportunity •Round table consultation •Research process-experience + alternatives	**Internal factors** •Cost + funding dependency •External/ project factors	•Group orientated idea generation	•Effectively resource concept •Shared ownership + vision •Ensure concept lead in time •Presentation + sale of concept •Facilitate team contribution
Component only	•Innovation process occurs during design phase •Design meeting presentation •Est. development meetings •Seek permission + funding •Plan management support	•**Internal factors** •Ability culturally of support	•Est. project team/ culture	

Initial phase

	Phase process	External/ Internal	Cultural/ team	Management control system
Overall	•Develop/ plan innovation for practical application •Selling concept	**External factors** •Novelty/ experience- industry **Internal factors** •Complexity of project integration •Resource allocation	•Communication + regulations •Involved team (throughout) •Experience levels + support •Learning/ improvement culture	•Involve + empower stakeholders
System + Process	•Decision taken-			•Define roles + responsibility
System + Com	•Infrastructural development meetings		Acceptance + understanding	•Ensure monitoring + feedback •Lead in time/ adapt criteria
Process + Component	•Draw on experience •Assess feasibility + implications •Technical + financial assessment	**External factors** •Regulation/ standards		•Option appraisal
System only	•Formulation of conditions for the project specifics	**External factors** •Industries cultural acceptance	•Success dependent •Personal changes •Stakeholders + ownership	•Devise support system •Target softer issues •Define + facilitate culture •Spread risk + workload
Process only	•Assess integration + risk + impact	**Internal factors** •Ability to focus on innovation •External stakeholders	•Decision- making hierarchy •Questioning, positive, engaged •Sufficient lead in/ liaising time	•Flexibility + open to changes •Facilitate understanding •Learn- mistakes + experience •Project integration/ implications
Component only		**Internal factors** •Ability culturally of support	•Group orientated culture •Satisfaction of requirements •Accommodation + integration	•Flexible leadership + control •Informal/ reflective culture •Ensure communication flow •Sell concept + convince team

Formulation + development phase

	Phase process	External/ internal	Cultural/ team	Management control system
Overall	•Gauge difficulty in practice •Structural facilitation •Feedback + improvement + evaluation meetings •Resources provision + control	**Internal factors** •Complexity of integration •Project demands + pressures	•Communication flow- quality •Access + ownership + trust •Strength + stability- relations •Project stresses •Learning + listening culture	•Facilitation of learning curve •Performance monitoring + consider improvements •Effective leadership control
System + Process	•Dissemination of implications •Est. methodology + program		•Engage entire team/ all levels	
System + Com			•Flexibility + problem- solving	•Support workshops/ meetings •Involvement of stakeholders
Process + Component	•Ensure standards + quality	**•External factors** •Viability against regulations		
System only		**External factors** •Traditional industry culture **Internal factors** •Dropping of softer issues •Fluid design process		•Group responsibility culture •Facilitate culture + relations
Process only	•Cater for external stakeholders	**External factors** •Fortune of luck- climate etc **Internal factors** •Influence of stakeholders •Control of external factors	•Wider project impact	•Develop confidence + trust •Effective planning of changes •Remove unhelpful personal •Control of budget + resources
Component only	•Integration of contractors'- site access	**External factors** •Planning requirements – variability	•Questioning + blame free culture •Reality in practice- difficulty	•Standards + long term outlook

Implementation phase

	Phase process	External/ internal	Cultural/ team	Management control system
Overall			•Freedom + openness for discussion	•Facilitate blame free decision culture •Ensure objectivity of process
System + Process	•Facilitate management evaluation system			
System + Com	•Team meeting	•**External factors** •Government + industry agenda	•Contact + relations with industry media	
Process + Component	•Disseminate process externally	•**External factors** •Regulations + potential changes	•Relationship with regulator	•Monitoring
System only		•**Internal factors** •Cultural factors •Break up of team over course of project	•Relationship culture within team post implementation	
Process only	•Evaluation of integration of project/ innovation objectives	•**Internal factors** •Time pressures- tendency to skip stage	•Desire/ motivation to complete entire process	•Established cultural need for constant improvement
Component only		•**Internal factors** •Doubt over value of phase		

Handover phase

	Pre- selection	Requirements	Post selection
Overall	•Define characteristics required (personality + mindset)	•Established and stable relationship sought •Characteristics- personality, mindset, quality •Experience + familiarity with concept- aids process	
System + Process			
System + Com	•Contractor selection- determines success of process (innovation)		
Process + Component			
System only	•Planning of a rigorous and thorough process •Need to select early within the process	•Recognition/ acceptance, reasons for participation	•Feelings of trust and reduced feelings of risk •Participation and access to decision- making •Deep understanding and awareness •Innovation is not imposed
Process only	•Benefits of using an established or in- house team •Assess reputation within the industry •Local expertise + relationships useful	•Practical experience/ ability for implementation	•Use of workshops, meetings to familiarise with p.m. system •Ensure designer est. contact with regulator •Ensure team gains experience from others
Component only	•Criteria based on needs of organisation or project	•Quality of selection determines nature of process	•Established team selected to aid process •Long term relationships take less time to facilitation than fresh

Selection phase

Appendix D

Comparison of success factors with established thinking

Description

Referred to in chapter 9, appendix D provides a comparison of each of the 22 success factors against established sets of success factors for managing innovation based within other empirical contexts. Three tables are presented representing each of the groups of factors identified i.e. strategic, structural and cultural. The comparison aims to assess if the contrasts between the different sets mark a distinction relating to the principles behind the factors, or is based on the requirements of the empirical environment to which they are based. The comparison highlights the variation in both the number and depth of each within the set. Closer examination revealed that one factor identified within the set generated within this research, may correlate to up to three factors within an established set. However, analysis reveals that the contrasts between the sets were not based a distinction between the principles, but rather the nature of the empirical context, and the depth of understanding of that environment. 22 success factors were identified in this context due to the specific nature of the construction project environment, and the level of detail that was understood relating to this.

Comparison of strategic success factors affecting the innovation process

Strategic	Cooper (2001)	Francis (2000)	Dooley + O'Sullivan (2000)	Tidd et al (1997, 2003)	Jones + Saad (2003)	Ahmed (1998)	Rothwell (1994)
Ensure + facilitate integration of the aims/ objectives of the project with the innovation (project level)	• Sharp and early product/ project definition • Well conceived, properly executed launch • Right organisational structure • Top management support • Levering core competencies • Go/ kill decision points • Resource allocation	• Innovation leadership • Full competencies portfolio • Capable implementation • Innovation demanded • Adapt organisational form • Guiding mental maps	• Organisation + group leadership • Strategic and performance measurement • Reengineering + improvement • Empowerment + groups • Learning + communication	• Appropriate structure and key individuals	• Treating innovation as a corporate wide task • Adopting a strategic approach in the management of innovation • Top management commitment and acceptance of risk		• Careful project management • Effective implementatio n
Established innovation culture/ methodology	• Well conceived, properly executed launch	• Prudent radicalism • Innovation demanded • Continuous	• Strategic and performance measurement • Learning and communications	• Vision of the future	• Treating innovation as a corporate wide task • Top management commitment and	• Culture of innovation • Importance of internal structure of	• Willingness to take on new ideas • Treating innovation as a

	• Go/ kill decision points • Disciplined multistage process	learning • High performing NP-PD	• Reengineering + improvement		acceptance of risk • Systematic approach to developing, implementing, monitoring and sustaining innovation	entrepreneur-ship	corporate wide task
Engagement with industry/ government agenda's-regulation + external environment	• Product superiority • Strong market orientation • Market attractiveness	• Provides strategic advantage	• Strategy + performance measurement		• Identification of a clear need for change • Responsiveness to internal and external change		• Strong market orientation • Long term strategy in which innovation plays a key role
Ensure project standards are met	• Levering core competencies • Focus on quality of process	• Full competencies portfolio • Capable implementation	• Strategy and performance measurement				• Careful project management • Up to date equipment
Integration of the needs of the team-individual objective for the project (team level)		• High enrolment • Fruitful linkages • Sustained commitment	• Reengineering and improvement • Organisational and group leadership • Empowerment and groups	• Learning organisation	• The achievement of good linkages within and between organisations leading to more collaborative relationships • Developing a	• Importance of sharing, of the big team • Importance of a culture of equals	• High and developing human capital

					sustaining a supporting organisational culture for innovation		

Comparison of structural success factors for the innovation process

Structural	Cooper (2001)	Francis (2000)	Dooley + O'Sullivan (2000)	Tidd et al (1997, 2003)	Jones + Saad (2003)	Ahmed (1998)	Rothwell (1994)
Provision of effective leadership + control - top- level participation	• Top management support • Go/ kill decision points • Resource allocation • Disciplined multistage process	• Innovation leadership • Innovation demanded Supportive champions • Sustained commitment	• Organisation + group leadership	• Visionary leadership and a will to innovate • Appropriate and key individuals	• Adopting a strategic approach in the management of innovation • Top management commitment and acceptance of risk • Presence of certain key individuals or champions • Systematic approach to developing, implementing, monitoring and sustaining innovation	• Importance of execution • Managing the external and internal image • Effective processing of ideas	• Presence of key people including product champions and technology gatekeepers • Top management support for innovation • Commitment to major projects • Top management acceptance of risk and termination criteria
Ensure access provided to entire team (involvement, all stakeholders, empowerment)	• Right organisationa l structure	• Exceptional individuals • Selective empowerment • High enrolment	• Empowerment and groups	• High involvement in innovation		• Value of people • Cross-function interaction • Importance	

		• Sound decision processes				of sharing, of the big team • Importance of a culture of 'equals'	
Fully consider research + experience (internal + externally)	• Strong market orientation • World product- seek • More predevelopment work (homework) • Levering core competencies	• Full competencies portfolio • Continuous learning • Acquiring multiple perspectives	• Learning and communications	• Learning organisation	• Responsiveness to internal and external change • Effective and on-going learning process	• Keeping and building knowledge	
Ensure monitoring of the process	• Right organisational structure • Top management support	• Innovation leadership	• Strategy and performance measurement		• Effective and on-going learning process	• Reporting structures and idea channels	• Careful project management
Facilitate communication + information pathways (listening culture)	• Speed within process	• Adapt organisational form	• Learning + communication			• Effective processing of ideas	• Good internal + external communications
Clearly define	• Sharp and		• Organisation +	• Appropriate		• Clarity of	

roles + responsibilities	early product/ project definition		group leadership	structure and key individuals		goals for innovation	
Effective selection of mindset of team		• Exceptional individuals	• Empowerment + groups	• Team operations development of individuals			• Willingness to take on new ideas
Ensure sufficient lead in time + resource allocation (understanding + selling of concept)	• More predevelopment work (homework) • Well conceived, properly executed launch • Resource allocation vital • Speed within process		• Reengineering + empowerment • Organiansition and group leadership	• Appropriate structure and key individuals	• Effective and on-going learning process	• Freedom + space to innovate	• Up- to date equipment
Provide facilitation support system	• Right organisational structure • Focus on quality of process	• Capable implementation • Adapt organisational form • Sustained commitment	• Reengineering + improvement • Strategy + performance measurement	• Appropriate structure and key individuals	• Systematic approach to developing, implementing, monitoring and sustaining innovation	• Social interaction • Accepting failure • Rewarding failure + success	• High and developing human capital

Develop and provide technical + financial assessment (feasibility + suitability)	• Market attractiveness • Go/ kill decision points	• Prudent radicalism • Full-competencies portfolio	• Strategy and performance measurement		• Identification of a clear need for change		

Comparison of cultural success factors for the innovation process

Cultural	Cooper (2001)	Francis (2000)	Dooley + O'Sullivan (2000)	Tidd et al (1997, 2003)	Jones + Saad (2003)	Ahmed (1998)	Rothwell (1994)
Ensure and develop acceptance + understanding - Justification	• Top manage-ment support • Levering core competencies • Market attractiveness	• Supportive champions	• Organisation and group leadership	• Visionary leadership and a will to innovate	• Identification of a clear need for change • The achievement of good linkages within and between organisations leading to more collaborative relationships • Top management commitment and acceptance of risk • Presence of certain key individuals or champions	• Clarity in goals for innovation	• Presence of key people including product champions and technology gatekeepers • Top management acceptance of risk and termination criteria • Creation of an innovation-accepting, entrepreneurship-accommodating culture
Ensure participation + involvement (ownership, workload, empowerment)	• Right organisati-onal structure	• Selective empowerment • High enrolment	• Empowerment + groups	• High involvement in innovation • Team operations	• Presence of certain key individuals or champions	• Cross functional interaction • Rewarding success + failure	

		• Fruitful linkages • Sustained commitment		development of individuals			
Develop and facilitate a proactive innovation culture (improvement + questioning)		• Prudent radicalism • Exceptional individuals • Innovation demanded • Continuous learning • Supportive champions	• Learning + communications • Reengineering + improvement	• Creative climate • Learning organisation	• Responsiveness to internal and external change • Treating innovation as a corporate wide task • Developing a sustaining a supporting organisational culture for innovation • Effective and on- going learning process	• Culture of innovation • Importance of trying	• Willingness to take on new ideas • Creation of an innovation-accepting, entrepreneurship-accommodating culture
Develop a creativity/ problem-solving culture	• Product distinction	• Prudent radicalism • Innovation demanded • Acquiring multiple perspectives	• Learning and communications	• Creative climate	• Treating innovation as a corporate wide task • Effective and on- going learning process	• Freedom + space to innovate • Keeping and building knowledge	• Willingness to take on new ideas • Creation of an innovation-accepting, entrepreneurship-accommodating culture

Ensure the balance + the continuity of the team (stability)		• Selective empowerme -nt	• Empowerment + groups	• Team operations developmen t of individuals	• The achievement of good linkages within and between organisations leading to more collaborative relationships	• Importance of a culture of equals	
Develop + facilitate a group + team culture (relationships)		• High enrolment • Sound decision processes	• Empowerment + groups	• Team operations developmen t of individuals • High involvement in innovation	• The achievement of good linkages within and between organisations leading to more collaborative relationships • Developing a sustaining a supporting organisational culture for innovation • Presence of certain key individuals or champions •	• Social interaction • Value of people • Importance of sharing, of the big team	• High and developing human capital

Facilitate impact on culture as a consequence of the project's performance	• Top managem ent support	• Innovation leadership • Supportive champions	• Reengineering + improvement • Learning + communication • Organisation + group leadership	• Learning organisation	• Developing a sustaining a supporting organisational culture for innovation	• Accepting failure	• Careful project management • Top management support for innovation • Long term strategy in which innovation plays a key role • Commitment to major projects